SCIENCE

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MSS. intended for publication and books, etc., intended for review should be sent to the responsible editor, Professor J. McKeen Cattell, Garrison-on-Hudson, N. Y.

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II.

ANOTHER question of widely general, and of peculiar mathematical interest, is the problem first attacked by Fourier, of the distribution and consequent effects of the earth's internal heat. The most interesting phase of this question is that which relates to the time that has elapsed since the crust of the earth became stable and sufficiently cool to support animal life. It is now nearly forty years since Lord Kelvin* startled geologists especially by telling them that Fourier's theory of heat conduction forbids anything like such long intervals of time as they were in the habit of assigning to the aggregate of paleontological phenomena. On several occasions since then Kelvin has restated his arguments with a cogency that has silenced most geologists if it has not convinced most mathematicians. Quite recently, however, the question has become somewhat less one-sided, since geologists and paleontologists are beginning to defend their positions† while that of

* In a memoir 'On the secular cooling of the earth,' *Trans. Royal Society of Edinburgh*, 1862. Republished in Kelvin and Tait's Treatise on Natural Philosophy, appendix D. Kelvin's latest paper on this subject is entitled 'The age of the earth as an abode fitted for life,' and is published in *Philosophical Magazine*, January, 1899; also in SCIENCE, May 12, 1899.

† See Professor T. C. Chamberlin's paper, "Lord

Kelvin is being attacked from the mathematical side.* My own views on this subject were expressed somewhat at length ten years ago, in the address already referred to, and it seems unnecessary here to go into the matter any further than to reaffirm my conviction that the geologists have adduced the weightier arguments. Beautiful as the Fourier analysis is, and absorbingly interesting as its application to the problem of a cooling sphere † is, it does not seem to me to afford anything like so definite a measure of the age of the earth as the visible processes and effects of stratification to which the geologists appeal. In short, the only definite results which Fourier's analysis appears to me to have contributed to knowledge concerning the cooling of our planet are the two following, namely: first, that the process of cooling goes on so slowly that nothing less than a million years is a suitable time unit for measuring the historical succession of thermal events; and secondly, that this process of cooling goes on substantially as if the earth possessed neither oceans nor atmosphere.

It was the well-founded boast of Laplace in the early part of the century that astronomy is the most perfect of the sciences;* and expert contemporary opinion, as we have seen in the case of no less a personage than Green, agreed that the 'Mécanique Céleste' left little room for further advances. Indeed, it would appear that the completeness and the brilliancy of the developments of celestial dynamics during the half century ending with 1825 (the period of Laplace's activity) completely overshadowed all other sciences and retarded to some extent the progress of astronomy itself. The stupendous work of Laplace was chiefly theoretical, however, and he was content in most cases with observational data which accorded with theory to terms of the first order of approximation only. He was probably not so profoundly impressed as men of science at this end of the century are with the necessity of testing a theory by the most searching observational means available. In fact, in elaborating his methods and in applying his theories to the members of the solar system, it has been essential for his disciples to display a degree of ingenuity and a persistence of industry worthy of the master himself. But the prerequisite to progress in celestial mechanics consisted not so much in following up immediately the lines of investigation laid down by Laplace, as in perfecting the methods and in increasing the data of observational astronomy.

Kelvin's address on the age of the earth as an abode fitted for life,' SCIENCE, June 30, 1899; also Sir Archibald Geikie's presidential address to Geological Section of the British Association for the Advancement of Science, Dover meeting, 1899.

* Notably by Professor John Perry. See *Nature*, January 3, and April 18, 1895.

† I have recast this problem of Fourier in two papers published in the *Annals of Mathematics*, Vol. III., pp. 75–88 and pp. 129–144. The solution there given is the only one, so far as I am aware, which lends itself to computation for all values of the time in the history of cooling. A point of much mathematical interest on which this solution depends is the equivalence of the two following series:

$$ru = \frac{2r_0u_0}{\pi}\sum_{n=1}^{n=\infty}\left(\frac{-1}{n}\right)^{n+1} e^{-a^2(n\pi/r_0)^2 t}\sin n\pi\frac{r}{r_0},$$

$$= ru_0 - \frac{2r_0u_0}{\sqrt{\pi}}\sum_{n=0}^{n=\infty}\int_{(2n+1)m_0-m}^{(2n+1)m_0+m} e^{-z^2}dz.$$

In these u is the temperature at a distance r from the center of the sphere at any time t; u_0 is the initial uniform temperature of the sphere; r_0 is the radius of the surface of the sphere; a^2 is the diffusivity, supposed constant; and $m = r/(2\sqrt{t})$, $m_0 = r_0/(2a\sqrt{t})$. It will be observed that when the first series (which is Fourier's) converges very slowly, the second converges very rapidly, and vice versa. It will be seen also, that the series refuse, as they should, to give values of the temperature corresponding to negative values of the time.

* "L'Astronomie, par la dignité de son objet et par la perfection de ses théories, est le plus beau monument de l'esprit humain, le titre le plus noble de son intelligence." Système du Monde, Ed., 1884, p. 486.

The development of this branch of science along with the development of the closely related science of geodesy, is a work essentially of the present century, and must be attributed chiefly to the German school of astronomers led by Gauss and Bessel. It is to these eminent minds, as well known in pure as in applied mathematics, that we are indebted for the theories, and for the most advantageous methods of use, of instrumental appliances, and for the refined processes of numerical calculation which secure the best results from observational data. It is a fortunate circumstance, perhaps, considering the irreverence which some modern pure mathematicians show for numerical computations, that Gauss and Bessel began their careers long before the resistless advent of the theory of functions and the theory of groups.

The story of the opportune discovery of the planet Ceres, as related by Gauss himself in the preface to his Theoria Motus Corporum Cœlestium, is well known; but it is less well known that the merit of this magnificent work lies rather in the model groups of formulas presented for the precise numerical solution of intricate problems than in the facility afforded for locating the more obscure members of the solar system. Indeed, the works of Gauss and Bessel are everywhere characterized by a clear recognition of the important distinction between those solutions of problems which are, and those which are not, adapted to numerical calculation. They showed astronomers how to systematize, to expedite, and to verify arithmetical operations in ways which were alone adequate to the accomplishment of the vast undertakings which have since been completed in mathematical geodesy and in sidereal astronomy.

Among the most important contributions of these authors to geodesy and astronomy in particular, and to the precise observational sciences in general, is that branch of the theory of probability called the 'method of least squares.'* No single adjunct has done so much as this to perfect plans of observation, to systematize schemes of reduction, and to give definiteness to computed results. The effect of the general adoption of this method has been somewhat like the effect of the general adoption by scientific men of the metric system; it has furnished common modes of procedure, common measures of precision, and common terminology, thus increasing to an untold extent the availability of the priceless treasures which have been recorded in the century's annals of astronomy and geodesy.

When we pass from the field of observational astronomy to the more restricted but more intricate field of dynamical astronomy, it is apparent that Laplace and his contemporaries quite underestimated the magnitudes of the mathematical tasks they bequeathed to their successors. Laplace, almost unaided, had performed the unparalleled feat of laying down a complete outline of the 'system of the world'; but the labor of filling in the details of that outline, of bringing every member of the solar system into harmony at once with the simple law of gravitation and with the inexorable facts of observation, is a still greater feat which has taxed the combined efforts of the most acute analysts and the most skillful computers of the preceding and present generation.

It is impossible within the limits of a semi-popular address to do more than mention in the most summary way the extraordinary contributions to dynamical astronomy made especially during the present

* Gauss's fundamental paper in this subject is "Theoria combinationis observationum erroribus minimis obnoxiæ," and dates from 1821. Werke, Band IV.

Bessel's numerous contributions to this subject are found in his "Abhandlungen" cited above.

half century, contributions alike formidable by reason of their bulk and by reason of the complexity of their mathematical details. An account of the theory of the perturbative function, or of the theory of the moon, for example, would alone require space little short of a volume.* To mention only the most conspicuous names, there is the pioneer and essentially prerequisite work of the illustrious Gauss and the incomparable Bessel. There is the remarkable work of the brilliant Leverrier (1811–1877), and the not less brilliant Adams (1819–1892),† well known to popular fame by reason of what may be called their mathematical discovery of the planet Neptune. Then came the monumental 'Tables de la Lune'‡ from the arithmetical laboratory of the indefatigable Hansen; and this marvellous production was quickly followed (1860) by the equally ponderous, and mathematically more important, 'Théorie du Mouvement de la Lune'§ from the pen of the admirably fertile and industrious Delaunay. And finally, there is the still more elaborate work, bringing this great problem of the solar system well-nigh to completeness of solution, which, by common consent, is credited to the two preceding presidents of the American Mathematical Society.‖ Probably no mathematico-physical undertakings of the century have yielded so many definite, quantitative results to the permanent stock of knowledge as the researches in dynamical astronomy.

But notwithstanding the astonishing degree of perfection to which this science has been brought, there are still some outstanding discrepancies which indicate that the end of investigation is yet a long way off. The moon, which has given astronomers as well as other people, more trouble than any other member of the solar system, is still devious to the extent of a few seconds in a century. The earth, also, it is suspected, is irregular as a time-keeper by a minute but sensible amount;* while it has been proved recently by the exquisite precision of modern observations, that the earth's axis of rotation wanders in a complex way through small but troublesome angles from its mean position, thus causing variations in the astronomical latitude of a place.†

*A good account of the progress in dynamical astronomy from 1842 to 1867 is given by Delaunay in 'Rapport sur les Progrès de l'Astronomie,' Paris, 1867.

†The papers of Adams have been edited by Professor W. G. Adams and supplied with a biographical memoir by Professor J. W. L. Glaisher, under the title 'Scientific Papers of John Couch Adams,' Cambridge, at the University Press, Vol. I., 1896.

‡Published by the British government in 1857.

§ *Mémoires de l'Académie des Sciences de l'Institut Impérial de France*, Tomes XXVIII., XXIX.

‖For an account of the more recent work of Gyldén and Poincaré, reference is made to the presidential address of Dr. G. W. Hill, "Remarks on the progress of celestial mechanics since the middle of the century"; *Bulletin American Mathematical Society*, 2d series, Vol. II., No. 5, p. 125.

*The effect of tidal friction on the speed of rotation of the earth appears to have been first explained by Ferrel in a 'Note on the influence of the tides in causing an apparent acceleration of the moon's mean position.' This paper was read before the American Academy of Arts and Sciences, in December, 1864, only a few weeks before Delaunay read a similar paper before the French Academy. See Ferrel's autobiography cited above. See also Delaunay's account of his own work in 'Rapport sur les progrès de l' astronomie,' Paris, 1867.

†The cause of such variations is found in the relative mobility of the parts of the earth, especially in the mobility of the oceans and atmosphere. Three types of variation may occur, namely: 1st, that due to sudden changes in the relative positions of the parts of the earth's mass; 2d, that due to secular changes in position of those parts; and 3d, that due to periodic shiftings of those parts. Of these the most important appears to be the periodic type. A surprising, and as yet not fully explained, discrepancy brought to light by the discovery of latitude variations is the fact that the instantaneous axis of rotation of the earth makes a complete circuit around the axis of figure in about 428 days, instead of in about 305 days as has been supposed from the time of Euler down to the present decade. The discovery of this discrepancy is due to

A question of intense interest to astronomers in the early part of the century is that of the stability of the solar system. Lagrange, Laplace, and Poisson thought they had demonstrated that, whatever may have been the origin of this system, the existing order of events will go on indefinitely. This conclusion seems to have been alike satisfactory to scientific and unscientific men. But with the growth of the doctrine of energy and with the developments of thermodynamics, it has come to appear highly probable that the solar system has not only gone through a long series of changes in the past, but is destined to undergo a similarly long series of vicissitudes in the future. In other words, while our predecessors of a century ago thought the 'system of the world' stable, our contemporaries are forced to consider it unstable.*

But interesting as this question of stability still is, there is no pressing necessity, fortunately, for a determination of the ulterior fate of our planet. A more important question lies close at hand, and merits, it seems to me, immediate and serious investigation. This question is the fundamental one whether the beautifully simple law of Newtonian attraction is exact or only approximate. No one familiar with celestial mechanics or with the evidence for the law of gravitation as marshalled by Laplace in his 'Système du Monde' can fail to appreciate the reasons for the profound conviction, long held by astronomers, that this law is exact. But on the other hand no one acquainted with the obstinate properties of matter can now be satisfied with the Newtonian law until it is proved to hold true to a much higher degree of approximation than has been attained hitherto.* For, in spite of the superb experimental investigations made particularly during the past quarter of a century by Cornu and Baille,† Poynting,‡ Boys,§ Richarz and Krigar-Menzel,|| and Braun,¶ it must be said that the gravitation constant is uncertain by some units in the fourth significant figure, and possibly by one or two units even in the third figure;** thus falling, along with the sun's parallax, the annual stellar aberration, and the moon's mass, amongst the least well determined constants of the solar system. Here then is a fruitful field for research. The direct measurement of the gravitation constant to a much higher degree of precision seems to

Dr. S. C. Chandler and was announced in the *Astronomical Journal*, No. 248, November, 1891. For the mathematical theory of this subject and for titles of the principal publications bearing on this theory, reference may be made to the author's paper on 'Mechanical interpretation of variations of latitudes,' *Astronomical Journal*, No. 345, May, 1895; and to a paper by S. S. Hough on 'The rotation of an elastic spheroid,' *Philosophical Transactions*, No. 187, 1896.

* See a review of this subject by M. H. Poincaré, "Sur la stabilité du système solaire," in *Annuaire du Bureau des Longitudes*, for 1898.

* As to the degree of precision with which the Newtonian law is established by astronomical data, see Professor Newcomb's "Elements of the four inner planets and the fundamental constants of astronomy," Supplement to American Ephemeris and Nautical Almanac for 1897, Washington, 1895.

† *Comptes rendus*, LXXVI., 1873.

‡ The Mean Density of the Earth, by J. H. Poynting, Chas. Griffin & Co., London, 1894.

§ *Philosophical Transactions*, No. 186, 1895.

|| Sitzungsberichte, Berlin Academy, Band 2, 1896.

¶ *Denkschriften*, Math. Natur. Classe, Vienna Academy, Band LXIV., 1897.

** The results of the investigators mentioned for the gravitation constant are, in C. G. S. units, as follows, the first result having been computed from data given by MM. Cornu and Baille in the publication referred to:

Cornu and Baille (1873)	6668×10^{-11}
Poynting (1894)	6698×10^{-11}
Boys (1894)	6657×10^{-11}
Richarz and Krigar-Menzel (1896)	6685×10^{-11}
Braun (1897)	6658×10^{-11}

Regarding these as of equal weight, their mean is 6673×10^{-11} with a probable error of ± 5 units in the fourth place, or 1/1330th part. This is of about the same order of precision as that deduced by Professor Newcomb from astronomical data.

present insuperable obstacles; but may not the result be reached by indirect means, or may it not be possible to make the solar system break its Sphinx-like reticence of the centuries and disclose the gravitational mechanism itself?

Just as the theories of astronomy and geodesy originated in the needs of the surveyor and navigator, so has the theory of elasticity grown out of the needs of the architect and engineer. From such prosaic questions, in fact, as those relating to the stiffness and the strength of beams, has been developed one of the most comprehensive and most delightfully intricate of the mathematico-physical sciences. Although founded by Galileo, Hooke, and Mariotte in the seventeenth century, and cultivated by the Bernoullis and Euler in the last century, it is, in its generality, a peculiar product of the present century.* It may be said to be the engineer's contribution of the century to the domain of mathematical physics, since many of its most conspicuous devotees, like Navier, Lamé, Rankine, and Saint-Venant, were distinguished members of the profession of engineering; and it is a singular circumstance that the first of the great originators in this field, Navier, should have been the teacher of the greatest of them all, Barré de Saint-Venant.† Other great names are also prominently identified with the growth of this theory and with the recondite problems to which it has given rise. The acute analysts, Poisson, Cauchy, and Boussinesq, of the French school of elasticians; the profound physicists, Green, Kelvin, Stokes, and Maxwell, of the British school; and the distinguished Neumann (Franz Ernst, 1798–1895), Kirchhoff (1824-1887), and Clebsch (1833–1872), of the German school; have all contributed heavily to the aggregate of concepts, terminology, and mathematical machinery which make this at once the most difficult and the most important of the sciences dealing with matter and motion.

The theory of elasticity has for its object the discovery of the laws which govern the elastic and plastic deformation of bodies or media. In the attainment of this object it is essential to pass from the finite and grossly sensible parts of media to the infinitesimal and faintly sensible parts. Thus the theory is sometimes called molecular mechanics, since its range extends to infinitely small particles of matter if not to the ultimate molecules themselves. It is easy, therefore, considering the complexity of matter as we know it in the more elementary sciences, to understand why the theory of elasticity should present difficulties of a formidable character and require a treatment and a nomenclature peculiarly its own.

While it would be quite inappropriate on such an occasion to go into the mathematical details of this subject, I would recall your attention for a moment to the surprisingly simple and beautiful concepts from which the mathematical investigation proceeds rapidly and unerringly to the equations of equilibrium or motion of a particle of any medium. The most important of these are the concept which relates to the stresses on the particle arising from its connection with adjacent parts of the medium, and

* An admirable history of this science, dealing with its technical aspects, was projected by Professor Isaac Todhunter and completed by Professor Karl Pearson, under the title "A History of the Theory of Elasticity and the Strength of Materials from the time of Galilei to the present time." Cambridge, at the University Press: Vol. I., Galilei to Saint-Venant, 1886; ol. VII., Parts I. and II., Saint-Venant to Lord Kelvin, 1893.

A capital though abridged history of the science is given by Saint-Venant in his annotated edition of Navier's Résistance des Corps Solides, troisième édition, Paris, 1864.

The history of Todhunter and Pearson is dedicated to Saint-Venant, who has been fitly called 'the dean of elasticians.'

† And this illustrious master has left a worthy pupil in M. J. Boussinesq, Professor in the Faculty of Sciences, Paris.

the concept with regard to the distortions of the particle which result from the stresses. If the particle be a rectangular parallelopiped, for example, these stresses may be represented by three pressures or tensions acting perpendicularly to its faces together with three tensions acting along, or tangentially to, those faces. Thus the adjacent parts of the medium alone contribute six independent force components to the equations of equilibrium or motion; and the stresses, or the amounts of force per unit area, which produce these components are technically known as tractions or shears according as they act perpendicularly to or tangentially along the sides of the particle.* Corresponding to these six components there are six different ways in which the particle may undergo distortion. That is, it may be stretched or squeezed in the three directions parallel to its edges; or, its parallel faces may slide in three ways relatively to one another. These six different distortions, which lead in general to a change in the relative positions of the ends of a diagonal of the parallelopiped, are measured by their rates of change, technically called strains, and distinguished as stretches or slides according as they refer to linear or angular distortion.†

It is from such elementary dynamical and kinematical considerations as these that this theory has grown to be not only an indispensable aid to the engineer and physicist, but one of the most attractive fields for the pure mathematician. As Pearson has remarked, "There is scarcely a branch of physical investigation, from the planning of a gigantic bridge to the most delicate fringes of color exhibited by a crystal, wherein it does not play its part."* It is, indeed, fundamental in its relations

* The terminology here used is that of Todhunter and Pearson, History of the Theory of Elasticity and Strength of Materials, Vol. I., Note B.

† The terminology and symbology of the theory of elasticity appear to be more highly developed than those of any other mathematical science. A comparison of the terms and symbols of elasticity with those of the older subject of hydromechanics, as shown, in part, below, is instructive:

IN ELASTICITY.

Stresses.		Strains.	
Tractions	p_{xx}	Stretches	s_x
	p_{yy}		s_y
	p_{zz}		s_z
Shears	p_{yz}	Slides	σ_{yz}
	p_{zx}		σ_{zx}
	p_{xy}		σ_{xy}

Shifts, or components of displacement: u, v, w

Shift-fluxions, or space rates of change of shifts: $\frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}, \frac{\partial u}{\partial z}$, $\frac{\partial v}{\partial x}$, etc., $\frac{\partial w}{\partial x}$, etc.,

Dilitation, $\theta = s_x + s_y + s_z = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}$

Twists:

$$\tau_{yz} = \frac{1}{2}\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right)$$

$$\tau_{zx} = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right)$$

$$\tau_{xy} = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)$$

Displacement potential in irrotational, or pure, strain.

IN HYDROMECHANICS.

Fluid pressure p

Component velocities: u, v, w

Space rates of change of component velocities: $\frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}, \frac{\partial u}{\partial z}$, $\frac{\partial v}{\partial x}$, etc., $\frac{\partial w}{\partial x}$, etc.,

Expansion, $\theta = \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial w}{\partial z}$

Component spins, or components of molecular rotation:

$$\xi = \frac{1}{2}\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right)$$

$$\eta = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right)$$

$$\zeta = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right)$$

Velocity potential in irrotational motion.

* History of Elasticity, etc., Vol. I., p. 872.

to the theory of structures, to the theory of hydromechanics, to the elastic solid theory of light, and to the theory of crystalline media.

In closing these very inadequate allusions to this intensely practical and abstrusely mathematical science, it is fitting that attention should be called to the magnificent labors of the 'dean of elasticians,' M. Barré de Saint-Venant. It was the object of his life-work to make the theory of elasticity serve the utilitarian purposes of the engineer and at the same time to divest it so far as possible of all empiricism. His epoch-making memoir* of 1853, on the torsion of prisms, is not only a classical treatise from the practical point of view, but one of equal interest and importance in its theoretical aspects. His investigations are everywhere delightfully interesting and instructive to the physicist; and many parts of them are replete, as observed by Kelvin and Tait,† with "astonishing theorems of pure mathematics, such as rarely fall to the lot of those mathematicians who confine themselves to pure analysis or geometry, instead of allowing themselves to be led into the rich and beautiful fields of mathematical truth which lie in the way of physical research." More important still in a didactic sense are his annotated edition of Navier's 'Résistance des Corps Solides,' of 1864, and his annotated edition of the French translation of the 'Theorie der Elasticität fester Körper,' of Clebsch, which appeared in 1883. These monumental works, whose annotations and explanatory notes quite overshadow the text of the original authors, must remain for a long time standard sources of information as to the history, theory, methods and results of this complex subject. The luminous exposition, the penetrating insight into physical relations, and the scientific candor in his criticism of other authors, render the work of Saint-Venant worthy of the highest admiration.

Closely allied to the theory of elasticity, though historically much older, is the science of hydromechanics. The latter is, indeed, included essentially in the former; and probably the great treatises of the next century will merge them under the title of molecular mechanics. It may seem somewhat singular that the mathematical theory of solids should have originated so many centuries later than the theory of fluids; for at first thought, tangible though flexible solids would appear much more susceptible of investigation than mobile liquids and invisible gases. But a little reflection leads one to the conclusion that it was, in fact, much easier to observe the data essential to found a theory of hydromechanics than it was to discover the principles which led to the theory of stress and strain; and the time interval between Archimedes and Galileo may serve perhaps as a rough measure of the relative complexity of hydrostatics and the theory of flexure and torsion of beams. It must not be inferred, however, that the simplicity of the phenomena of fluids in a state of relative rest extends to the phenomena of fluids in a state of relative motion; for the gap that separates hydrostatics from hydrokinetics is one which has not yet been fully bridged even by the aid of the powerful resources of modern mathematics.

The elements of hydrokinetics, with which branch of hydromechanics this sketch is alone concerned, were laid down by Euler about the middle of the last century.* It

* 'Mémoire sur la torsion des prismes,' etc., published in *Mémoires des savants étrangeres*, Tome XIV., 1855.

† Natural Philosophy, 2d ed., Part II., p. 249.

* 'Principes géneraux du mouvement desflui des.' *Histoire de l'Académie de Berlin*, 1755.

'De Principiis motus fluidorum.' *Novi Commentarii Academiæ, Scientiarum Imperialis Petropolitanæ*, Tomus XLV., Pars I., pro anno 1759.

is to him that we owe the equations of motion of a particle of a 'perfect fluid.' This is an ideal fluid, moving without friction, or subject, in technical terminology, to no tangential stress. But while no such fluids exist, it is easily seen that under certain circumstances this assumed condition approaches very closely to the actual condition; and, in accordance with the method of mathematico-physical science in untangling the intricate processes of nature, progress has proceeded by successive steps from the theory of ideal fluids toward a theory of real fluids.

The history of the developments of hydromechanics during this century has been very carefully and completely detailed in the reports to the British Association for the Advancement of Science of Sir George Gabriel Stokes,* in 1846, and of Professor W. M. Hicks,† in 1881 and 1882. And the history of the subject has been brought down to the present time by the address of Professor Hicks before Section A of the British Association for the Advancement of Science in 1895, and by the report‡ of Professor E. W. Brown to Section A of the American Association for the Advancement of Science in 1898. It may suffice here, therefore, to glance rapidly at the salient points which mark the advances from the state of the science as it was left by Lagrange a hundred years ago.

The general problem of the kinetics of a particle of a 'perfect fluid' is easily stated. It is this:* given for any time and for any position of the particle its internal pressure, its density, and its three component velocities, along with the forces to which it is subject from external causes; to find the pressure, density, and velocity components corresponding to any other time and to any other position. There are thus, in general, five unknown quantities requiring as many equations for their determination. The usual six equations of motion, or the equations of d'Alembert, contribute only three to this required number, namely, the three equations of translation of the particle, since the three which specify rotation vanish by reason of the absence of tangential stress. A fourth equation comes from the principle of the conservation of mass, which is expressed by equating the time rate of change of the mass of the particle to zero. This gives what is technically called the equation of continuity. A fifth equation is usually found in the law of compressibility of the fluid considered.†

Now, the equations of rotation, as just stated, refuse to answer the question whether the particles proceed in their

* 'Report on recent researches in hydrodynamics,' Report of British Association for the Advancement of Science for 1846.

† 'Report on recent progress in hydrodynamics,' Reports of British Association for the Advancement of Science for 1881 and 1882.

‡ 'On recent progress towards the solution of problems in hydrodynamics,' Proceedings of American Association for the Advancement of Science for 1898. See also SCIENCE, November 11, 1898.

Reference should be made also to Professor A. E. H. Love's paper 'On recent English researches in vortex-motion,' in the *Mathematische Annalen*, Band XXX., 1887.

* The statement here given is that of the 'historical method,' which seeks to follow a particle of fluid from some initial position to any subsequent position and to specify its changes of pressure, density and speed. What is known as the 'statistical method,' on the other hand, directs attention to some fixed volume in the fluid and specifies what takes place in that volume as time goes on.

† The five equations in question are

$$\frac{du}{dt} = X - \frac{1}{\rho}\frac{\partial p}{\partial x}, \qquad \frac{d(V\rho)}{dt} = 0,$$

$$\frac{dv}{dt} = Y - \frac{1}{\rho}\frac{\partial p}{\partial y},$$

$$\frac{dw}{dt} = Z - \frac{1}{\rho}\frac{\partial p}{\partial z}, \qquad p = f(\rho);$$

in which p is the pressure and ρ is the density at the centroid (x, y, z) of the particles; V is its volume; u, v, w are its component velocities; and X, Y, Z are the force components per unit mass arising from external causes.

orbits without rotation or whether they undergo rotation along with their motion of translation. This was a critical question, for the failure to press and to answer it seems to have retarded progress for nearly half a century. Lagrange, and after him Cauchy and Poisson, knew that under certain conditions* the differential equations of motion are integrable, but they do not appear to have understood the physical meaning of these conditions. It remained for Sir George Gabriel Stokes to show that the Lagrangian conditions of integrability correspond to the case of no molecular rotation, thus clearly distinguishing the two characteristic types of what we now call irrotational and rotational motion.† Such was the great step made by Stokes in 1845; and it furnishes a forcible illustration of the importance, in applied mathematics, of attending to the physical meaning of every symbol and every combination of symbols.

Thirteen years later came the remarkable memoir of Helmholtz (1821–1894) on the integrals of the equations of hydrokinetics for the case of rotational, or vortex, motion.‡ This memoir is alike wonderful for the directness with which the mathematical argument proceeds to its conclusions and for the clearness of insight it affords of the physical phenomena discussed. In short, it opened up a new realm and supplied the results, concepts, and methods which led the way to the important advances in the science made during the past three decades.

Another powerful impulse was given to hydrokinetics, and to all other branches of mathematical physics as well, by Kelvin and Tait's Natural Philosophy—the Principia of the nineteenth century—the first edition of which appeared in 1867. From this great work have sprung most of the ideas and methods appertaining to the theory of motion of solids in fluids, a theory which has yielded many interesting and surprising results through the researches of Kirchhoff, Clebsch, Bjerknes, Greenhill, Lamb and others. Of prime importance also are the numerous contributions of Lord Kelvin to other branches of hydrokinetics, and particularly to the theory of rotational motion.* In fact, every department of the entire science of hydromechanics, from the preliminary concepts up to his vortex atom theory of matter, has been illuminated and extended by his unrivalled fertility.

When we turn to the more intricate branch of the subject which deals with the motion of viscous fluids, or with the motion of solids in such fluids, it appears that the progress of the century is less marked, but still very noteworthy. This branch is closely related to the theory of elasticity, and goes back naturally to the early researches of Navier, Poisson and Saint-Venant; but the revival of interest in this, as well as in the less intricate branch of the subject, seems to date from the fruitful memoir† of Stokes, of 1845, and from his report to the British Association for the Advancement of Science of 1846. Since then many interesting and useful problems relative to the flow of viscous fluids and to

* That is, when $udx + vdy + wdz$ is a perfect differential, u, v, w being velocity components; or, when

$$\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}, \quad \frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}, \quad \frac{\partial v}{\partial x} - \frac{\partial u}{\partial x},$$

which are the doubles of the components of molecular rotation, vanish, these latter being the conditions for the existence of a velocity potential.

† This discovery of Stokes was announced in his fundamental paper 'On the theories of internal friction of fluids in motion, and of the equilibrium and motion of elastic solids,' *Transactions of the Cambridge Philosophical Society*, Vol. VIII. Reprinted also in his Mathematical and Physical Papers, Vol. I.

‡ "Ueber Integrale der hydrodynamischen Gleichungen, welche den Wirbelbewegungen entsprechen," *Crelle's Journal für die reine und angewandte Mathematik*, 1858.

* 'On vortex motion,' 1867. *Transactions of the Royal Society of Edinburgh*, Vol. XXV.

† Cited above.

the motion of solids in such media, have been successfully worked out to results which agree fairly well with experiment. But on the whole, notwithstanding the searching investigations in this field of Stokes, Maxwell, Helmholtz, Boussinesq, Meyer, Oberbeck, and many others, it must be said that difficulties, both in theory and in experiment, of a formidable character remain to be surmounted.*

Of all branches of hydromechanics there is none of so great practical utility and of such widely popular interest as the theory of tides and waves. These phenomena of the sea are appreciable to the most casual observer; and there has been no lack of impressive descriptions of their effects from the days of Curtius Rufus down to the present time. The mechanical theory of tides and waves is, however, a distinctly modern development whose perfection must be credited to the labors of the mathematicians of the present century.†

Here, again, progress is measured from the advanced position occupied by Laplace, who was the first to attempt a solution of the tidal problem on hydrokinetic principles. After the fundamental contributions of Laplace, contained in the second and fifth volumes of the 'Mécanique Céleste,' the next decisive advance was that made by Sir George Airy (1801–1892), in his article on tides and waves, which appeared in the Encyclopædia Metropolitana in 1842. A quarter of a century later came the renaissance, started undoubtedly by the great memoir of Helmholtz and by the Natural Philosophy of Kelvin and Tait, along with Lord Kelvin's inspiring communications on almost every phase of wave and tidal problems to scientific societies and journals. Then followed the decided theoretical improvements in tidal theory of Professor William Ferrel,* particularly in the development of the tide generating potential and in the determination of the effects of friction. And a little later there appeared the novel investigations of Professor G. H. Darwin, who, in addition to furnishing a complete practical treatment of terrestrial tides,† has extended tidal theory to the solar system and thrown an instructive light on the evolutionary processes whence the planets and their satellites have emerged and through which they are destined to pass in the future.‡

As we reflect on the progress which has been thus summarily, and quite inadequately outlined, it will appear that the mathematicians of the nineteenth century have contributed a splendid aggregate of permanent accessions to knowledge in the domain of the more exact of the physical sciences. And as we turn from the certain past to the less certain future, one is prone to conjecture whether this brilliant progress is to continue, and, if so, what part the

*An extremely interesting method of experimental investigation has been recently applied with success by Professor Hele-Shaw. See a paper by him on 'Stream-line motion of a viscous film,' and an accompanying paper by Sir G. G. Stokes on 'Mathematical proof of the identity of the stream-lines obtained by means of a viscous film with those of a perfect fluid moving in two dimensions.' Report of British Association for the Advancement of Science for 1898.

† An excellent summary of the history and theory of tides, and of methods of observing and predicting them, is given by Dr. Rollin A. Harris in his 'Manual of Tides,' published as Appendices 8 and 9 of the Report of the U. S. Coast and Geodetic Survey for 1897.

* 'Tidal Researches.' Appendix to Report of U. S. Coast and Geodetic Survey for 1874, Washington, 1874.

† In article on tides in Encyclopædia Britannica, 9th edition.

‡ Darwin's investigations are published in a series of papers in the *Philosophical Transactions of the Royal Society of London*, Parts I., II., 1879; Part II., 1880; Part II., 1881; Part I., 1882. They are republished in part in Appendix G, Thomson and Tait's Natural Philosophy, 2d edition. See also the capital semi-poplar work, 'The Tides and Kindred Phenomena in the Solar System,' by G. H. Darwin Boston and New York, Houghton, Mifflin & Co., 1889.

American Mathematical Society may play in promoting further advances. With respect to these enquiries I should be loath to hazard a prediction or to offer advice. But there appears to be no reason for entertaining other than optimistic expectations. The routes along which exploration may proceed are numerous and attractive. We have only to follow the example set by Laplace, Poisson, Green, Gauss, Maxwell, Kirchhoff, Saint-Venant, Helmholtz, and their eminent contemporaries and successors. In commending the works of these great masters to the younger members especially of the American Mathematical Society, I would not be understood as urging the cultivation of pure mathematics less, but rather as suggesting the pursuit of applied mathematics more. The same sort of fidelity to research and the same sort of genius for infinite industry which enabled those masters to accomplish the grand results of the nineteenth century, may be confidently expected to achieve equally grand results in the twentieth century.

R. S. Woodward.

Columbia University.

CRUISE OF THE ALBATROSS.

II.

The following letter from Dr. Agassiz, dated Papeete Harbor, Tahiti Island, November 6, 1899, has been received by the United States Fish Commission and is here published by courtesy of Commissioner Bowers.

During our stay in Papeete some time was spent in examining that part of the barrier reef of Tahiti which had been surveyed by the *Challenger*. We found the condition of the outer slope of the reef quite different from its description as given in the *Challenger* narrative. The growing corals were comparatively few in number, and the outer slope showed nothing but a mass of dead corals and dead coral bowlders beyond 16 or 17 fathoms, few living corals being observed beyond 10 to 12 fathoms.

We also made an expedition to Point Venus, to determine, if possible, the rate of growth of the corals on Dolphin Bank from the marks which had been placed on Point Venus by Wilkes, in 1839, and by MM. Le Clerk and de Bénazé, of the French navy, in 1869. We found the stones and marks as described, but, in view of the nature and condition of Dolphin Bank, did not think it worth while to make a careful survey, as Captain Moser had intended to do. On examining Dolphin Bank in the steam launch I was greatly surprised to find that there were but few corals growing on it. I could see nothing but sparsely scattered heads, none larger than my fist, the top of the bank being entirely covered by nullipores. We sounded across the bank in all possible directions and examined it thoroughly, and at the stage of water at which we sounded, found about 18 inches difference from the soundings indicated by the charts. It is also greatly to be regretted that Dolphin Bank was not examined, neither in 1839 nor in 1869, and notes made of what species of corals, if any, were growing on its surface; for an excellent opportunity has been lost to determine the growth of corals during a period of 60 years. The choice of this bank as a standard to determine the growth of corals was unfortunate, as it is in the midst of an area comparatively free from corals.

Extensive collections have been made at Papeete during our visit by the naturalists of the *Albatross*.

After refitting and coaling here, we left on the 5th of October for a cruise in the Paumotus.

We steamed for Makatea, which we had visited on our way to Tahiti, and not only examined the island more in detail, but took a number of photographs of the cliffs

on the east side, which, on our first trip, we passed late in the afternoon. We crossed the island from west to east, the path leading down from the summit of the cliffs bordering the island into a sink at least 40 to 50 feet lower than the rim of either face of the island. The sink occupies a little more than one-third the length of the island. It is deeper at its southern extremity, where it is said to be 75 to 100 feet below the rim of the adjoining cliffs.

It is difficult to determine if this sink is the remnant of the former lagoon of the island, or of a sound formed during its elevation; or if it has been formed by the action of rain and atmospheric agencies. The amount of denudation and erosion to which this island has been subjected is very great, as is clearly indicated by the small cañons, pinnacles, and walls of limestone, as well as by the crevasses which occur in the surface of the basin in all directions. The extent to which this action has penetrated into the mass of the island is also plainly shown by the great number of caverns which crop out at all levels along the sea face of the cliffs, some of which are of great height, and extend as long galleries into the interior of the island. It is, of course, difficult, in the face of this extensive denudation and erosion, to state positively what may be part of the ancient lagoon, or sound, and what has been carried away by atmospheric and other agencies since the elevation of the island. At the south end of the island, which is lower than the northern part, there are only two distinct terraces, while at the northern end four terraces can be traced. The southern extremity, however, is still higher than the deepest part of the central sink of the island.

From Makatea, we visited Niau, Apataki, Tikei, Fakarava, Anaa, Tahanea, Raroia, Takume, Makemo, Tekokota, Hikueru, Marokau, Hao, Aki-Aki, Nukutavake, going as far east as Pinaki, when we turned westward again to Nukutipipi.

On arriving at Pinaki we decided to give up the exploration of the eastern extremity of the Paumotus, and not to make our contemplated visit to the Gambier Islands, our time having been greatly curtailed by delays at Fakarava and Makemo, from bad weather and the non-arrival of our coal supply. We therefore reluctantly turned westward again and made for the Gloucester Islands. These, as well as Hereheretue, proved most interesting; they formed, as it were, an epitome of what we had seen on a gigantic scale in the larger atolls of the western and central Paumotus. We could see at a glance in such small atolls as Nukutipipi and Anu-Anurunga, the connection between structural features which, in an atoll 40 miles in length and from 10 to 15 miles in width, it was often difficult to determine.

Except at Nukutavake we found no village in which the habits of the natives had not been more or less modified by civilization. The Paumotu Islanders have practically given up building their own houses; they use European models and their roofs are composed in great part of galvanized iron. There are also but few of the original native canoes to be seen. In a few years all traces of their customs and crafts will have disappeared.

We also steamed by Kauehi, Tænga and Tuanaka. We anchored in Fakarava and Makemo lagoons, spending a number of days in both these atolls. We usually timed our visits to the islands where we could not anchor so as to spend the day, or the greater part of the day, at these atolls, making our passages at night, and sounding whenever practicable on the way.

After leaving Tahiti we made over 100 soundings. These have shown in a general way that the western islands are probably all on a great plateau connected perhaps by

the 800-fathom line; that such islands as Anaa are probably on spurs or independent smaller plateau, separated from the main plateau by somewhat deeper water. The same may be the condition of Raroia and Takume and of Hao and Amanu, while such smaller and isolated peaks as Tikei, Aki-Aki, Nukutavake, and Pinaki, as well as the Gloucester Islands, rise from greater depths and are isolated peaks. At any rate, these soundings indicate, as do the soundings off the Fijis, that atolls do not necessarily rise from very great depths, and that in this characteristic atoll district, atolls are found, it is true, with steep slopes, but rising from moderate depths. The slopes of these atolls would probably resemble in every respect the slope of the elevated coralliferous limestone islands characteristic of the Lau Group in Fiji.

The deepest sounding among the Paumotus was on the line to the northward of Hereheretue in the direction of Mahetia, where we found a depth of 2524 fathoms, and a continuation of the red clay characterizing the soundings since we left Pinaki. In nearly all the soundings among the Paumotus, even at moderate depths not far from the atolls, we brought up manganese particles or small manganese nodules. The last haul, made in deep water on the way from Hereheretue, in 2440 fathoms, brought up at least half a ton of manganese nodules, the bottom being red clay.

We have now steamed about 2500 miles among the Paumotus, and although we had not the advantage of the accurate surveys of the English hydrographic charts, which made the exploration of Fiji so easy, yet from the structure of these atolls it was a comparatively simple task, by steaming around the islands and landing wherever practicable, to get a fairly good idea of their structure. We have seen nothing in this more extended examination of the group tending to show that there has anywhere been subsidence. On the contrary, the condition of the islands of the Paumotus cannot, it seems to me, be explained on any other theory except that they have been formed in an area of elevation; an area of elevation extending from Matahiva on the west to Pinaki in the east, and from the Gloucester Islands on the south to Tikei in the north, although the islands in the line of Mangareva to Tahiti are separated from the other Paumotus by a deep channel, nearly 200 miles wide and more than 2400 fathoms in depth, with scattered islets and atolls extending from Mangareva to Pinaki, and northward to Serle Island and beyond, islands which are not connected with the extensive plateau upon which the greater number of the Paumotu Islands to the westward of Hao rise.

All the islands we have examined are, without exception, formed of tertiary coralliferous limestone which has been elevated to a greater or less extent above the level of the sea, and then planed down by atmospheric agencies and submarine erosion, the greatest elevation being at Makatea (about 230 feet), and at Niau, where the tertiary coralliferous limestone does not rise to a greater height than 20 feet. At Rairoa it was 15 to 16 feet high. At other islands it could be traced only as forming the shore platform, from 50 to 150 feet wide, which forms the outer face of the Paumotus, and is so characteristic a feature of the atolls of the group. In other parts the old ledge could be traced cropping up in the interior of the outer rim, or in the open cuts connecting the lagoon with the outer sea face of the atolls. Everywhere the space between the outcropping of the old ledge, as I will call the tertiary coralliferous limestone, was filled with beach rock, or a pudding stone, or with a breccia or conglomerate of coralliferous material consisting in part of fragments of the old ledge and of fragments of recent corals and shells cemented together.

The appearance of the old ledge and of the modern reef rock is so strikingly different that it is very simple to distinguish the two, even when only comparatively small fragments are found.

We did not find in the Paumotus, as in Fiji, all possible stages of denudation and of submarine erosion between islands like Vatu Vara, Niau, Kambara, Fulanga, Ongea, Oneata, Ngele Levu, and Weilangilala, and atolls with a mere ring or surf to indicate their existence.

In the Paumotus the islands have been elevated to a very moderate height and probably to nearly the same height, for the old ledge forming the base of the modern structure is found exposed nearly everywhere at about low-water when it cannot be traced at a slightly greater elevation. This would readily account for the nearly uniform height of the islands throughout the group.

But there is another element which comes into play in this group, and has an important part in shaping the ultimate condition of these atolls. At the Fijis we have seen the submarine erosion continue until there is little left of many of the atolls beyond the merest small islet or rock to indicate its structure. In the Paumotus, in the great atolls which are evidently only the exposed summits of parts of ridges or spurs of an extensive tertiary coralliferous limestone bed, the rim of the atoll is, after having been denuded to the level of the sea, again built up from the material of its two faces which is thrown up on the wide reef flats both from the sea face and from the lagoon side. We do not find in the Fijis such huge reef shelves to supply such masses of material from the breaking up of the outer and inner edges of the tertiary limestone platforms, in addition to the fragments of recent corals growing upon the flat and its edges, which, when dead, are thrown up and formed into shingle and sand to form a pudding stone, or a conglomerate, or breccia, with the fragments of the old ledge on the top of the reef flats.

This pudding stone, or beach rock, is found on all the reef flats of the islands of the group. It forms great bars, at right angles usually to the shore-line, and upon the sea-face of these bars is thrown up coral shingle, both old and recent, which builds up short reaches of beaches separated by wide flats through which the sea rushes at high water, or merely covers the flats at low tide; while on the lagoon side of the wide reef flats a similar process is going on, throwing up finer sand among the beach-rock bars and along their sides, and thus building up, little by little, at first small sand bars, then larger bars, or islets, at right angles to the shore-line, and as they become larger by accretions from both sides, they finally form an island from 1000 to 1200 feet long, according to the width of the reef flat, extending from the lagoon edge of the flat to the sea face of the atoll. The sand bars, little by little, become covered with vegetation, and at some stages of tide appear like islands and islets situated a considerable distance within the lagoon. Whenever the material supplied both from the lagoon side and from the sea face is very abundant, the land ring becomes more or less solid, the islets become consolidated into islands, separated by narrow or wider cuts, until finally they form the larger islands which seem at first glance to form continuous land along the rim of the lagoon, but which are often seen to be separated according to local conditions by narrow cuts, which finally allow no water to pass through and merely indicate the former separation of the various parts of the land.

In the lagoons of atolls of such great length as some of these of the Paumotus, like Rairoa, Fakarava, Makemo and Hao, which are between 30 and 40 miles long,

and others of less dimensions, considerable sea rises under the prevailing trades. The sea and wind generally follow the trend of the shores, both in the lagoon and along the sea face, so that the bars of beach rock act like buttresses and collect material at their inner and outer extremities, forming the sand bars and islets which eventually become the land rim of the lagoon. When the material is not from local causes very abundant, or is washed out over the flats, there are fewer islands, and often these are but mere islets or bars for long reaches of the shore, forming the characteristic weather faces of many of the lagoons.

Many of the lagoons are filled with shoals or ledges awash or a few feet above the sea-level. These shoals are parts of the old ledge which have not as yet been eroded, and the disintegration of which has gone far to supply material for the land of the outer rims of the atolls. In Fakarava there were no less than 36 islands and islets and ledges, parts of a former great flat, now broken up, existing parallel to the outer reef flat about four miles in the lagoon. Similar reef flats exist in Tahanea, where they form a secondary lagoon with two to three fathoms of water, extending nearly the whole length of the western face of the atoll. There are several large islands on this flat, and at high water they would appear as the islands and islets of Fakarava do, as disconnected and planted in the lagoon itself. A secondary lagoon also exists in Ravahere and Anaa; in both these atolls the reef flat extends across one extremity of the lagoon and does not run parallel to the longer shore-line of the atoll.

The lagoons of these atolls have a general depth of 13 to 20 fathoms. In some cases they are, as is stated, somewhat deeper (but there are no measurements), the greater depths being 30 fathoms or more, being due to orogenic conditions. Some of the atolls are quite shallow, as at Matahiva as well as Pinaki, where the lagoon is not more than two to three fathoms, and Takume, where it is from five to six fathoms deep. Some of the smaller islets we visited, among which are Tekei, Aki-Aki and Nukutavake, have no lagoons. The former has a shallow sink in which fresh water collects, but the rim is only very slightly higher than the interior. The last two islets are apparently depressed in the center, three to four feet below the outer bank of sand which forms the rim (about 10 to 12 feet high) of the basin of the island. I was at first inclined to look upon these islands as examples of islands which had been cut down to the level of the sea and subsequently been built up by beach rock and sand in the manner described above. The existence of extensive sand dunes on two sides of the island at Pinaki, and of a large dune (estimated to be 35 feet high) on the south shore of Nukutavake, seems to indicate the possibility of there having been a shallow lagoon occupying the center of Aki-Aki and of Nukutavake, and that these lagoons were gradually filled by the sand dunes, much as Pinaki is filling now.

At Pinaki (Whitsunday Island), there is no doubt but that the lagoon is rapidly filling from the sand blown in by the dunes. They are from 12 to 15 feet high and are forcing their way in towards the lagoon, killing the pandanus and whatever vegetation there is growing on the land rim of the lagoon. The dunes have probably filled also a second entrance to the lagoon, indicated now only by a somewhat lower level of the land rim. Mr. Moore and Mr. Townsend, who went ashore at Pinaki, report that the lagoon is not more than three fathoms deep; they could wade over the greater part of it. Mr. Alexander counted no less than 116 islets in this small lagoon —less than a mile in diameter—islets formed of masses of dead Tridacna shells thrown up on ledge rock, on the slopes of

which grew madrepores. The bottom of the lagoon is covered by Tridacna and masses of a species of Arca live near the edge, the intervening spaces being filled with nullipores. The entrance to the lagoon is perhaps 150 feet wide, and there is a cut through the beach rock covering the old ledge, giving access to the sea into the lagoon at certain stages of the tide. The water in the lagoon is quite warm.

At Pinaki, as at other atolls and islets to the eastward, there are fewer cocoanuts than on the westward atolls, and the vegetation consists in great part of pandanus and puteau trees and the usual coral reef vegetation of the Paumotus and Fijis.

The only atoll we have seen, the lagoon of which is entirely shut off from the sea, is Niau. In this case the old ledge forming the rim of the land, which surrounds the nearly circular lagoon, is about a third of a mile in width, and sufficiently high, 15 to 20 feet, to prevent any sea from having access to it except in case of a cyclone, as that of 1878, when the sea washed into the lagoon. The lagoon is shallow, of an average depth of about three fathoms, the deeper parts perhaps five. The water is brackish, of a density of 1.0216 at 28 degrees C. There are no corals living in it, but a species of mullet is found, as well as many marine shells, which, like those in the lagoons of San Salvador, in the Bahamas, are of diminutive size compared to their representatives living outside. The floor of the lagoon is covered with algæ. The lagoon has probably a slight connection with the sea, the water percolating through the limestone ring separating it from the outer reef flat. It is very difficult in this case to decide whether this lagoon has been gradually filled up after elevation or whether it is merely a sink on a more or less uneven limestone surface.

Dana and the other writers on coral reefs mention a great number of lagoons as being absolutely shut off from the sea. I take it these statements are due to their descriptions being taken from charts, many of which (as in the case of the Paumotus) are very defective. For nothing is easier than to pass at a short distance by the wide and narrow cuts which give in so many places the freest access to the sea to the interior of the lagoons, and described as closed because they have no boat passages. I could mention as instances of such lagoons those of the atolls of Takume, Hikueru, Anaa, etc., which may be said to be closed, yet into which a huge volume of water is poured at every tide over low parts of the encircling reef flats.

The character of the coral reefs of the Paumotus is very different from that of other coral reef regions I have seen. Nowhere have I seen such a small number of genera, so many small species, and such stunted development of the corals. None of the great heads of the genera so characteristic of the West Indian regions, or of the great barrier reef of Australia, are to be seen; with the exception of a couple of species of alcyonaria they are absent, so far as our experience shows, and there are but few sponges and gorgonians to be found among the corals. The bathymetrical limit of the reef-building corals seems to be about 20 to 22 fathoms, but nowhere have I seen such extraordinary development of incrusting nullipores as on the sea edge of the shore platforms of some of the Paumotu atolls, where they build up to a height often four feet to form the outer edge of the secondary barrier reef so frequently seen along the reef faces of the Paumotus.

On the 4th of November we were well on our way to Mehitia, the easternmost of the Society Islands, the account of which will be included in my next letter giving the results of our examination of the Society Islands.

We have taken a large number of photo-

graphs to illustrate the structure and mode of formation of the Paumotu atolls. Mr. Mayer has devoted much time to the drawing of the medusæ collected.

Judging from the temperature taken at various points, 40° F. seems to be found quite generally at about 500 fathoms depth.

We made a number of surface hauls, as well as intermediate hauls, with the townets, but obtained very little animal life. The poverty of the surface pelagic life, and down to 300 fathoms, is remarkable. I do not think I have ever sailed over so extensive an area as that of the Paumotus and observed so little surface life; on calm days, under the most favorable conditions, nothing could be seen with the naked eye, and at night there was little or no phosphorescence. Inside the lagoons our hauls were equally barren.

The same paucity of animal life seemed to extend to the deep-water fauna. All the hauls we made off the islands, in from 600 to 1000 fathoms, usually the most productive area of a sea slope, brought nothing, or so little that we came to grudge the time spent in trawling on the bottom, as well as towing on the surface or near it, a great contrast to the conditions of the Atlantic in similar latitudes, and very different from our anticipations. For these reasons no attempt has thus far been made to make a trial of the deep-sea pump while in such unproductive areas, and unfortunately while we were in the region of the equatorial current the weather conditions were not suited for a trial of the apparatus.

We expect now to coal and refit, and to leave for Suva via Tonga on the 15th of this month. A. Agassiz.

THE TWELFTH ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

I.

The Geological Society of America convened at 10 a. m., Wednesday, December 27th, in the large lecture room of Columbia University, Washington, D. C. President B. K. Emerson called the meeting to order and Dr. G. K. Gilbert delivered an address of welcome, to which the President responded. The following officers were then declared elected for the ensuing year:

President: George M. Dawson, Ottawa, Ont.; *First Vice-President:* Charles D. Walcott, Washington, D. C.; *Second Vice-President:* N. H. Winchell, Minneapolis, Minn.; *Secretary:* H. L. Fairchild, Rochester, N. Y.; *Treasurer:* I. C. White, Morgantown, W. Va.; *Editor:* J. Stanley-Brown, Washington, D. C.; *Librarian:* H. P. Cushing, Cleveland, O.; *Councillors:* W. B. Clark, Baltimore, Md., and A. C. Lawson, Berkeley, Calif.

The following new Fellows were also announced as having received election:

Irving Prescott Bishop, 109 Norwood Avenue, Buffalo, N. Y., Professor of Natural Science, State Normal and Training School; Emilo Böse, Ph.D. (University of Munich, 1893), Calle del Paseo Nuevo No. 2, Mexico, D. F., Geologist of the Instituto Geologico de Mexico; Arthur Starr Eakle, B.S. (Cornell, 1892), Ph.D. (Munich, 1896), University Museum, Cambridge, Mass., Instructor in Mineralogy and Petrography, Harvard University; August Frederick Foerste, A.B. (Denison, 1887), A.M., Ph.D. (Harvard, 1888, 1890); John Flesher Newsom, A.B. (University, Indiana, 1891), A.M. (Stanford, 1892), Stanford University, Calif., Associate Professor of Metallurgy and Mining, Stanford University; Samuel Lewis Penfield, Ph.B., M.A. (Yale, 1877, 1896), New Haven, Conn., Professor of Mineralogy, Sheffield Scientific School of Yale University; Charles Henry Richardson, A.B., A.M., Ph.D. (Dartmouth, 1892, 1895, 1898), Hanover, N. H., Instructor in Chemistry and Mineralogy, Dartmouth College; Arthur Brown Willmott, B.A., B.Sc. (Victoria University, Toronto, 1887), M.A. (Harvard, 1891), Toronto, Canada, Professor of Geology and Chemistry, McMaster University.

During the year the Society has lost by death four of its most distinguished Fellows, of whom two, Sir J. William Dawson and Edward Orton, have been presidents. The others were O. C. Marsh and Oliver Marcy. Memorials were read of all but Professor Marsh, whose biographer, Professor C. E. Beecher, was absent, and had

failed to send his manuscript. Extemporaneous remarks were made after the reading of each of the memorials, and they were often marked by deep feeling, as one after another of the former students of the departed scientists paid his tribute to his old teacher and friend. The first paper was then read as follows:

Physiographic terminology with special reference to land forms. By W. M. DAVIS, Cambridge, Mass.

The paper embraced a critical discussion and a definition of terms, mostly suggested within the last thirty years, for the description of land forms. The terms cycle, base-level and grade were considered in detail.

The general principle was advocated that terms should be based on observation and should express its results. The geographical cycle was urged as the basis. Instead of the old conceptions of destructional and constructional; initial, sequential and ultimate were suggested. It was urged that for 'base-level' as applied to the limiting conditions of the development of a river 'graded slope' be substituted—as base-level has now a variety of meanings. Other terms involving the syllables 'sequent,' such as consequent, obsequent, insequent, subsequent, etc., were suggested and defined. In discussion B. K. Emerson referred to the difficulty of remembering the distinctions in meaning among so many similar terms, a remark that struck a sympathetic chord in the minds of all teachers present.

Camas Land, a valley remnant. By GEO. OTIS SMITH and GEO. CARROLL CURTIS, Washington, D. C., and Boston, Mass.

A description was given of the remnant of an old valley on the eastern slope of the Cascade Mountains, in Washington (Mt. Stuart quadrangle). Camas Land owes its preservation above the circumdenudation to an intrusive sheet of diabase. A relief model of Camas Land was exhibited which made clear to all present the peculiar phenomena of the region and the rearrangement of the drainage. Discussion by W. M. Davis and M. R. Campbell ensued, which, however, would require the model to be intelligible to one not present.

Some coast migrations, Southern California. By BAILEY WILLIS, Washington, D. C.

The section of the California coast described extends from Point Sur to Piedras Blancas, between Monterey and San Luis Obispo. Formations constituting the Santa Lucia Range of the Coast Ranges were described, their relations to each other stated, and the corresponding migrations of the Pacific Coast were indicated with probability. A review of the observations of Fairbanks was presented.

It was shown that the oldest rocks constitute a series of metamorphic schists and that on these rest the Jurassic, Cretaceous, Miocene and Pliocene series. The schists are intruded by granite. Five thousand feet above the Pacific the Miocene beds are met dipping eastward and thinning out in that direction. This indicates a great land area which must have existed in the Miocene, where now is the Pacific ocean; 3000 feet above the sea, folded Pliocene strata occur. There are, therefore, two submergences indicated and great elevation and disturbances in comparatively recent geologic time.

Submerged forest of the Columbia River. By G. K. GILBERT, Washington, D. C.

At the Cascades the Columbia river flows over a natural dam of rock fragments. In the pond above stand sound stumps of Douglas spruce. Of various explanations proposed that first suggested by Lewis and Clark and repeated by Gibbs and Newberry accords best with the facts. The river was dammed by a land slide from the north not less than 350 years ago.

The speaker reviewed the explanations

of other observers and the Indian legends. He showed the general topography and geology by means of maps, and explained his estimate of the lapse of time by the rings in the stumps of trees which had grown on the landslide. There is also a river terrace about 100 feet above the present water level. The landslide therefore ponded the river and drowned the trees standing above it. In discussion J. A. Holmes cited cypress trees, in good preservation, 20 feet below the bottoms of rivers in North Carolina, and G. B. Shattuck spoke of similar cases in Maryland in the Pleistocene.

Physiographic development of the Washington region. By N. H. Darton, Washington, D. C.

A general sketch was presented, illustrated by maps and photographic illustrations, and intended to give visiting geologists an outline of the principal features of the Mesozoic to recent geology.

The paper was not meant for publication, but it served to set before the Society an excellent idea of the geological formations near Washington and their physiographic development.

Erosion forms in the Harney Peak District, Black Hills, South Dakota. By Edmund Otis Hovey, New York City.

The paper consisted of the exhibition of about ten lantern slides, showing the peculiar forms produced by erosion in the schists and pegmatites in the Harney Peak District in the Black Hills of South Dakota.

The slides illustrated the curiously sheeted and jointed granite which leads to the production of very rough topography. Pictures of the large spodumene crystals at the Harney Peak tin mines were also thrown upon the screen.

In discussion President Emerson compared the spodumenes with those of Massachusetts. S. F. Emmons described the occurrence of the spodumenes in pegmatites. I. C. Russell inquired if there were evidences of glaciation in the hills; Mr. Hovey replied, no. A. C. Spencer inquired if the Sylvan Lake was a rock-basin. This was likewise answered in the negative.

Topographic features of Ohio. By W. G. Tight, Granville, O.

The general topographic features of the different sections of the State were discussed and an attempt was made to show the reasons for the different types. The paper was illustrated with lantern views.

The author remarked the paucity of information about the physiography of the State in general. He divided it into three areas: the northwestern, within the limits of the glacial ice; the border, a belt along the terminal moraine; and the southeastern, outside the drift. The readjustments of drainage and the various topographic forms were admirably illustrated. In discussion M. R. Campbell inquired if there was good evidence of peneplains in the southeast; the author replied that there was some but that it was not conclusive. I. C. White discussed the general directions of the drainage.

Drainage modifications in Southeastern Ohio. By W. G. Tight, Granville, Ohio.

The changes in drainage of the region north of the Ohio river and between the lower Muskingum and the lower Scioto have been very great. The lower Muskingum, south of Zanesville, is shown to be a composite stream made up of sections of four preglacial streams which crossed the course of the present Muskingum. These four streams united in what is now the Little Hocking basin, and the main line of preglacial drainage extended across the present Hocking river, which is also shown to be composed of sections of several preglacial streams, into the basin of Raccoon creek and across this basin into that of the Scioto river below Chillicothe. Several of

the tributaries of this preglacial river were also described.

The paper gave a very graphic conception of the rearrangements which were brought about by the continental ice sheet, changing the outlet of the river system from the Great Lakes to the Mississippi. In discussion M. R. Campbell brought up the Teazes valley and the changes in the Big Kanawha, and the presence of silt in the former. W. G. Tight then described the area covered by silt and referred the readjustment of the drainage to the obstruction which it presented. The silting was explained by some barrier far to the westward. I. C. White referred to his early description of the valley, and urged the danger of mistaking, for cols, narrows in the Ohio and other rivers produced by the crossing of some hard stratum. The author replied that he had sought to guard against this.

The landslides of the Rico Mountains, Colorado. By WHITMAN CROSS, Washington, D. C.

The Rico Mountains, in southwestern Colorado, are due to the erosion of a local domatic uplift. The sedimentary formations affected embrace the Algonkian, Devonian, Carboniferous, Permo-Carboniferous, Juratrias and Cretaceous. Many intrusive dikes, sheets and small laccoliths of diorite—or monzonite—porphyry occur in this complex. A large monzonite stock penetrates all rocks above mentioned. Intense and complicated faulting has taken place in the heart of the uplift, and there has been a great amount of mineralization, forming argentiferous ore bodies of many types.

Landslides, occurring in a recent geological epoch, are very prominent features of the local geology. These landslide areas were described, the relation of the phenomena to other elements of the geological history were discussed, and hypotheses of their origin set forth.

The landslides are limited to the central portion of the domatic uplift. No apparent connection can be traced between the structure and the slides, nor are they present in the region of greatest faulting. The speaker finally concluded that they were connected with deep, interior vulcanism, transmitted through the intruded stock of monzonite.

J. B. Woodworth mentioned similar cases in southwestern Montana, where water-bearing beds caused the slipping. W. M. Davis mentioned Alpine cases where glacial erosion had removed the support. Dr. Cross said there was no glaciation at Rico. W. H. Niles also referred to Alpine cases. Geo. Otis Smith mentioned similar cases in the Stewart mountains, Oregon, where, of all the rocks present, the granite is alone unaffected.

A recent fault scarp in the Lepini Mountains, Italy. By W. M. DAVIS, Cambridge, Mass.

The Lepini mountain group is a submaturely dissected block of cretaceous strata, 40 miles S. E. of Rome. Recent movement on the line of a tertiary fault has produced a well-defined scarp in places 100–200 feet in height and traceable five miles or more along the northeastern base.

The paper was finely illustrated by the lantern and the truncations of fan-like projections of rock called rock-fans were well shown. There was no discussion. The reading of the paper closed the first day's proceedings.

On Wednesday evening the President, Professor B. K. Emerson, delivered his presidential address upon 'The Tetrahedral Earth and the Zone of the Intercontinental Seas,' before a large gathering of the Society and their friends. It will appear in another number of SCIENCE.

The Society convened in business session Thursday morning at 9.30 o'clock. The

report of the Council was submitted and approved. Reports were received from the photographic committee which shows that a collection of over 1900 views has been made. The committee then resigned and N. H. Darton was elected a committee of one to have charge of the matter. A motion was passed approving of the organization of a Cordilleran Section to embrace the members living on the Pacific coast, who by reason of distance cannot meet with the Society, and a telegram of greeting was sent to them in their first session.

The report of the Council showed the Society to be in a very prosperous condition. There are 239 Fellows, besides the 8 elected at this meeting. The Society has an invested fund of $5,000, and on account of an unavoidable delay in issuing Vol. X, had also a balance, December 1st, of $3,030.02. The Society is, however, very anxious and ambitious to increase its invested funds in order that the income may admit of the suitable illustration of papers.

Deposits of calcareous marl in Michigan. By Israel C. Russell, Ann Arbor, Mich.

A large number of lakes and swamps in the southern Peninsula of Michigan have been found to contain deposits of calcareous marl suitable for the manufacture of Portland cement. The marl is composed in part of shells, but is mainly a chemical precipitate and is still being deposited. The better grades contain from 80 to 95 per cent. of calcium carbonate. Several large cement works have already been established and others are contemplated. The supply of marls is practically inexhaustible and Michigan can easily take a leading place in the Portland cement industry.

The precipitation of the calcareous matter is probably due to the fact that calcium carbonate is more soluble in cold water than in warm, and as the lakes are fed by springs, the waters rise in temperature and lose their dissolved material.

J. F. Kemp referred to the importance of the industry and the previous efforts that had been made near Syracuse to utilize the same materials. J. M. Clarke emphasized the possible part played by algæ in precipitating the calcium carbonate. The speaker replied that he had not found much evidence of them.

Glacial origin of the older Pleistocene in the Gay Head Cliffs, with a note on the fossil horse of that section. By J. B. Woodworth, Cambridge, Mass.

The occurrence of glaciated fragments in the boulder bed at the base of the older Pleistocene (Columbia) in the Gay Head Section was described and illustrated, confirming, it is thought, the theory of the existence of an ice invasion long antedating the surface moraines of the New England islands. The astragalus of a mammal identified with that of a horse, by Professor Osborn, was exhibited. This bone was found in the Miocene underlying the boulder bed at Gay Head.

Beach structure in Medina sandstone. By H. L. Fairchild, Rochester, N. Y.

The papers involved an exhibition, by lantern slides, of structural features in the Medina which indicate shallow water and beach deposits. The speaker referred to the phenomena described by G. K. Gilbert at a previous meeting as giant ripples, which suggested waves of 60 ft. height. Many views were shown illustrating them, and small ripple marks were seen on these crests. Individual cases without parallel neighbors were exhibited. The phenomena were then interpreted by the action of actual waves on the beach of Lake Ontario and they were explained as due to shore-wave action. C. W. Hayes cited similar phenomena on the San Juan River, Nicaragua, and H. S. Williams described chan-

nel fillings in the Devonian beds near Ithaca, which threw light on the cases in point.

Glacial erosion in the Aar Valley. By ALBERT PERRY BRIGHAM, Hamilton, N. Y.

Observations were made between Meiringen and the Abschwung. The valley has several relatively broad and open sections, containing small rock basins. These basins are filled with alluvial material. One double basin, however, that of the Grimsel Lakes, being out of the track of the stream, keeps its water-filling. Between the basins, in some cases, are narrow V-shaped gorges, bordered by heavily glaciated spurs thrown out from the valley sides. The sides of the gorges are often glaciated nearly to the bottom. In other cases rock barriers have crossed the valley and are now breached by very narrow post-glacial gorges, as above the Grimsel Hospice and above Meiringen. Supplementary illustrations were given from the Rhone and Visp Valleys.

W. M. Davis in discussion illustrated the discordance between side valleys and the main valley—the former discharging at an altitude of some hundreds of feet above the floor of the latter. These discordant, lateral valleys were called 'hanging valleys.' I. C. Russell remarked the same phenomena in the Sierras and Cascades. Bailey Willis emphasized the excess of lateral erosion by glaciers over the vertical and that thus the natural grade of the side valleys had been truncated. W. H. Niles laid stress on the importance of subglacial streams, along the sides of a glacier. G. K. Gilbert urged the efficiency of glacial erosion and stated that the profiles of lateral valleys did not coincide with the idea of truncation. The discordance may be met in rivers, as along the Rio Virgin, where the main stream deepens faster than the laterals. J. J. Stevenson corroborated the same views by the valley of the Twin Lakes in Colorado. J. W. Spenser described the hanging valleys of Norway, which are step-shaped at the discordance. I. C. White described discordance along the Monongahela Valley, where no glacier had ever existed. S. F. Emmons cited hanging valleys along the Columbia River, where it crosses the national boundary. H. W. Turner mentioned cases in the Sierras in the Bidwell Bar quadrangle. A. P. Brigham confirmed the power of a glacier to erode. W. M. Davis closed the discussion.

Movement of glaciers. By HARRY FIELDING REID, Baltimore, Md.

The paper gave the results of from one to three years' observations on the movement of the Forno glacier, with special reference to the vertical component of the movement. The existence of surfaces of finite shear in glaciers was discussed. The author described the set of stakes that he had set up at several places across the glacier and had watched for two or three years. They showed a slow movement at the end and a more rapid one up the ice-stream, and some interesting relations at the névé. He proceeded at once to the reading of his second paper.

Stratification and banded structure of glaciers. By HARRY FIELDING REID, Baltimore, Md.

Careful work on a number of the Swiss glaciers has enabled the author to follow the outcrops of the strata from the névé-line practically to the end of the glacier, and has convinced him that the banded structure is the modified appearance of the outcrops. A reason is suggested why glacialists have held divergent views on this subject. With a beautiful and complete series of lantern slides the author illustrated the evidences of stratification and the phenomena of movement. He distinguished

stratification lines from the banding due to pinched crevasses and to other causes, and discussed the differences of Agassiz and Forbes regarding these phenomena. Bailey Willis commented on the close parallelism between ice movement and rock movement and inquired regarding the phenomena of movement. Dr. Reid replied that there was no shearing at all, but that plasticity sufficed to explain all the observed phenomena.

A channeled drumlin. By H. L. Fairchild, Rochester, N. Y.

A few lantern views showed a longitudinal hollow (channel?) in a drumlin terminating at the lower end by a transverse cut.

The phenomena had puzzled the writer and after illustrating them he appealed to the Society in vain for an explanation.

Distinction between Upper and Lower Huronian. By A. P. Coleman, Toronto, Canada.

During the past summer a band of rock consisting of fine-grained sandstone, chert or jasper, with interbedded iron ore, has been found at Michipicoton, on the northeast shore of Lake Superior, corresponding to the Vermilion and other iron-bearing series west and south of Lake Superior. This band has been traced for 30 or 40 miles, and has been recognized at various points to the west as far as Rainy Lake and east to Lake Temagami. It is the most easily determined member of the Lower Huronian. Many fragments of this sandy, cherty or jaspery rock are found, as well-rounded pebbles in conglomerates of the Upper Huronian, at Gros Cap, a few miles west of Michipicoton, and at other points as far west as Shoal Lake and east as Lake Temiscaming, a distance of more than 600 miles. Jasper and other pebbles of these rocks furnish an easily applied test of the Upper Huronian, since their materials can have come only from the Lower Huronian. The basal conglomerates near Thessalon and also on Lake Temiscaming contain jasper pebbles, and hence indicate only the base of the Upper Huronian. This far-reaching break between the two parts of the series represents a great lapse of time, as proved by the Shoal Lake conglomerate.

In discussion C. D. Walcott disclaimed any conflict in the meaning of Algonkian and Huronian, making the former a much wider and more inclusive term than the latter.

The Cambrian formation in the Atlantic province. By Charles D. Walcott, Washington, D. C.

The work of Dr. G. F. Matthew and the use of the term Etcheminian series, by him, for a sedimentary series formerly considered to be pre-Cambrian and to be separated by a break from the Cambrian, was reviewed. The presence of a stratigraphic break between the Etchenimian and Cambrian was found not to exist. The apparent break is explicable by folds. The same relations were found in Newfoundland. Views were shown illustrating the Smith's Bay and Manuel's Brook localities.

The Lower Devonian aspect of the Lower Heidelberg and Oriskany formations. By Charles Schuchert, Washington, D. C.

The Silurian of Murchison was compared with the American equivalents. The Devonian of Sedgwick and Murchison has no marked Lower Devonic fauna. The Lower Devonic of Germany was summarized. The Helderberg fauna is transitional to the Oriskany, and these two constitute the American Lower Devonic.

The paper was read by J. M. Clarke and the next three titles were taken up before discussion was begun.

The Silurian-Devonian boundary in North America. By Henry S. Williams, New Haven, Conn.

The writer presented a discussion (*a*) of the principles to be used in determining the

boundary between the two systems, Silurian and Devonian, the standard sections of which are on another continent, and (*b*) of the facts of correlation bearing upon the case.

He urged that to establish the top of the Silurian as the word was used by Murchison, we must find the equivalent of the Tilestone fauna. This has been done in the Arisaig fauna of the Maritime provinces, which is well developed in northern Maine and which lies over the Helderberg fauna at the same place. He therefore developed an argument for retaining the Helderberg in the Silurian.

The contact of the Silurian and Devonian in Erie Co., N. Y. By A. W. GRABAU, Troy, N. Y.

A limestone known as the Bullhead rock was found to contain fossils like those described by Whitfield from the Helderberg of Ohio. There is an unconformity between the Bullhead rock and the overlying Onondaga. A sandstone dike in a crevice in the limestone was described and some suggestions regarding the choice of a name for the Bullhead rock were made. The Manlius limestone was finally adopted, it having been used by Dr. J. M. Clarke.

Devonian strata in Colorado. By ARTHUR C. SPENCER, Washington, D. C.

The presence of Devonian rocks in southwestern Colorado, asserted by F. M. Endlich in 1874, has been confirmed by observation of the United States Geological Survey party under the direction of Dr. Whitman Cross.

The section when complete is threefold, consisting of a conglomerate and sandstone at the base, followed by a calcareous shale, and this by a massive limestone containing considerable numbers of invertebrate fossils. The limestone is shown by its outcrops to have covered an area of at least 600 square miles. The sandstone and shale beds are locally absent through non-deposition. Their age is possibly Silurian, though they contain occasional fish remains, which would ordinarily be considered indicative of the Devonian. The silicious series is correlated with the 'Parting Quartzite' of central Colorado, and mention is made of further probable equivalency between this series and the supposed Devonian of the Grand Canyon region. This brings out the probability that these formations of the Middle Paleozoic were originally deposited over a very extensive area in the southern Rocky Mountain region.

The fossils have been studied by Dr. George H. Girty, who considers that they are representative of a fauna older than that of the Chemung, and probably belonging at the base of the upper Devonian or near the top of the lower. Collections made by various geologists in central Colorado, are found to contain the same assemblage of fossils and to afford a basis for correlation. The fauna resembles that described by Whiteaves, from Hay River, Canada.

All four Devonian papers were discussed together. J. M. Clarke urged, regarding the delimitation of the Silurian, that it should rest upon the organic forms and their culmination, and not on the classification of Murchison. He then emphasized the Devonian aspects of the Helderberg of New York most strongly, and stated that its rich fauna should decide the question and with it the Arisaig would go. Dr. Clarke also corroborated the observations of Grabau by his own studies in the cement quarries of Buffalo.

H. S. Williams stated his method of solving the Devonian question as an endeavor to find in America an equivalent section to the classic section of the Old World. He therefore had searched for it in Maine and had discovered one above the Helderberg, which was almost exactly equivalent to the Tilestone. Other con-

trasts were instanced. C. H. Hitchcock remarked the importance of northern Maine as a place to decide this question, and mentioned Lake Telos as a promising locality. H. S. Williams again spoke, bringing up the Gaspé section and mentioning facts about northern Maine. J. M. Clarke also remarked his acquaintance with the Devonian fossils from Maine and reaffirmed the finality of the organic tests of correlation.

These papers concluded the session of Thursday. In the evening at 7.30 o'clock the Society assembled at the Hotel Raleigh for the annual banquet. To the delight of all present, Professor Emerson was found at the head of the table, and as usual a very merry evening followed. According to the admirable custom, now well established, the fellows brought their wives, and the ladies gave a brilliant aspect to the dinner. Ninety-five covers were laid, including about 15 for ladies.

J. F. Kemp.

Columbia University.

SCIENTIFIC BOOKS.

Frontinus and the Water Supply of the City of Rome. By Clemens Herschel, Hydraulic Engineer. Boston, Dana Estes & Co. 1899. 4to. xlix + 296 pages.

Frontinus was appointed water commissioner of Rome in 97 A.D., and soon thereafter wrote his two books, generally called De Aquis, on its waterworks. The sole original Latin manuscript, dating from the twelfth or thirteenth century, is preserved in the library of a Benedictine monastery in Italy, and the photographic reproductions of its twenty-four pages which Mr. Herschel gives will be of interest to classical scholars. He also gives the Latin text and its English translation on facing pages, and adds twelve chapters of explanatory and critical matter which are of special value to civil engineers and archæologists; these are accompanied by eighty-four illustrations and three folding plates. This is the first time that De Aquis has appeared in English translation, and it is safe to say that no single volume has ever been published that contains such a wealth of information on the water supply of ancient Rome.

The treatise of Frontinus begins with a description of the nine aqueducts erected prior to 97 A.D., mentioning their builders, sources and lengths. The subject of water measurement is next discussed and the sizes of the standard pipes are given, this being preparatory to determining the amount of water furnished by each aqueduct and how much was used for fountains, for public buildings and for private uses. Then the quality of the waters and the laws for the prevention of pollution receive attention, and this is followed by a statement of the duties and powers of the water commissioners, and of the regulations for preventing the unlawful use of water. Lastly, the methods of repairing the aqueducts are discussed, and the laws for ensuring their proper maintenance are given.

Mr. Herschel discusses at length the engineering and hydraulic features of the aqueducts and of the methods of distributing the water. It is clearly shown that the Roman engineers had no rational methods of measuring water, such quantities as cubic feet per second or gallons per hour being beyond their powers of conception. The unit of measurement used by them was called a 'quinaria,' this being originally a circular pipe whose diameter was 1¼ Roman digits, later the number of square units in the cross-section of this circle, and later the quantity of water passing through this area. Evidently it was understood that the discharge through a pipe or channel would vary with the velocity, as Frontinus says that the aqueduct Virgo could not be properly measured near its source, where the current was too slow, but near the city where the velocity was greater he found it to give 2504 quinarias. In general, however, the measurement of water was made by finding the area, in quinarias, of the cross-section of the channel or pipe; thus a denaria pipe, whose diameter was double that of the quinaria pipe, was supposed to discharge four quinarias of water.

The statement is commonly made in cyclopædias that the aqueducts of ancient Rome delivered about 300 gallons of water per day for

each inhabitant, a consumption about three times as great as that of American cities. This statement is traced by Mr. Herschel to certain hypothetical computations published by Prony in 1817, which are shown to rest upon unwarranted assumptions. A probable value of the quinaria is found in three different ways: first, by computations from the measured cross-section of an aqueduct now standing and the ancient slope of its water surface as marked by the incrustations of the deposited limestone; second, by actual gaugings of those ancient aqueducts that are now in use; and third, by computations from reasonable data of the discharge of pipes which delivered water to houses. An analysis of the work of Blumenstihl and Belgrand leads to the conclusion that the value of the quinaria was somewhere between 2500 and 9000 gallons per day. Accepting the statement of Frontinus that 14,000 quinarias were delivered within the city, and calling its population one million, it follows that the consumption was between 35 and 126 gallons per person per day, and when it is considered that one or more of the aqueducts were generally out of service owing to the progress of repairs, the lower figure is probably nearer to the actual consumption. Mr. Herschel's final conclusion is that the probable daily consumption was 38 gallons per person, although the actual value doubtless varied some 20 gallons on either side of that figure.

The Roman laws regarding the injury of aqueducts, the pollution of their waters, and the unlawful use of water have formed the basis of modern statute law for the protection of public water supplies. Regarding the distribution of water to buildings, it is interesting to note that direct connections with the aqueducts and street mains were forbidden; these mains delivered the water to small distributing tanks, and a house connection was made to one of these tanks by a quinaria pipe. It was required by law that this pipe could not be increased in diameter within a distance of fifty feet from the tank, since by so doing the discharge would be increased. These water tanks were under the charge of men called 'aquarii,' who probably bought the water from the city and sold it to consumers, since various methods devised by them to defraud both the city and the consumers are described and severely denounced by Frontinus.

Roman arithmetic and mensuration form the subject of one of Mr. Herschel's interesting chapters, but his statement that Frontinus used for π the value $3\frac{1}{7}$ seems to be scarcely warranted. In fact the list of fractions used by Frontinus does not contain $\frac{1}{7}$, that list being $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{6}$, $\frac{1}{12}$, $\frac{1}{24}$, $\frac{1}{36}$, $\frac{1}{48}$, $\frac{1}{72}$, $\frac{1}{288}$, and multiples of these. From the diameters and circumferences of several pipes, as stated in De Aquis, the writer concludes that the value of π used in computing the latter from the former was probably $3\frac{41}{288}$, or, in the notation of Frontinus, $3 + \frac{1}{12} + \frac{1}{24} + \frac{1}{72} + \frac{1}{288}$.

Mr. Herschel remarks that Frontinus takes high rank, even to-day, as a practical superintendent of waterworks. His first care on assuming the office was to ascertain the history of the aqueducts and the regulations and customs regarding the measurement of the water; then he made gaugings to ascertain the amount of water carried by the aqueducts and the consumption. Finding the latter far less than the former, he traced the discrepancy to unlawful connections. The laws relating to these were then enforced and measures taken to prevent waste. The result was that "the cleanliness of the city is greatly improved, the air is purer, and the causes of pestilence are removed"; at the same time "those who with fear drew water unlawfully, draw their supply now free from care, by grant from the sovereign," and thus morality was promoted.

It is a matter of congratulation that the first English translation of Frontinus' De Aquis should have been made by a hydraulic engineer highly qualified to interpret it. In fact our knowledge of Frontinus and his work is mostly due, not to classical scholars, but to technical men, the French and German translations having been made by the civil engineers Rondelet and Dederich. The writer of a history of Rome, published at Boston in 1886, refers to the book of Frontinus as belonging "to the class which furnish facts without giving ideas." If, however, Frontinus be read carefully by those who are able to understand the facts, as scientists and civil engineers can do, it appears, as the

English translator well says, that many and valuable ideas may be obtained. The interesting commentaries contained in this volume render it possible for even the general reader to do this with pleasure and profit.

MANSFIELD MERRIMAN.

Gleanings from Nature. By W. S. BLATCHLEY. Indianapolis. 1899. 16mo. 348 pp., 15 pl., 100 cuts.

The State Geologist of Indiana has here given us a dozen or more chapters on the natural history of his State, with the laudable purpose of interesting young people in the objects about them. If but a fraction only of the 800,000 children to whom he dedicates the book will read it, the results should be good; for the author speaks at first hand of all he writes, and seems equally at home whether discoursing of quadrupeds, birds, reptiles, fishes, insects, trees, weeds or caverns, to which latter feature of southern Indiana much space is given. We have noticed but one serious error, where the femora of *Mantis* are taken for tibiæ. The stories are simply told, and derive their chief value from being the outcome of close personal contact with nature and from their local flavor. The book is to be heartily recommended to the young people not only of Indiana but of the neighboring states, to which it is nearly as well adapted. It will take them out of doors on every page and awaken a new interest in living nature. The illustrations are mostly good, many excellent and all to the purpose. There is a sufficient index.

S. H. S.

LIVERPOOL MARINE BIOLOGICAL COMMITTEE'S MEMOIRS.

THE appearance of No. I., of the Liverpool Marine Biological Committee's 'Memoirs on Types of British Marine Plants and Animals,' deserves more attention from teachers and students of natural history than the intrinsic scientific value of the volume, however much this may be, can justly claim. This because of the uniqueness in several ways of the series which this number introduces. In the first place these volumes are to be unique in the matter of price. Who has ever before heard of a bound volume, in the English tongue at least, on a natural history subject, written by a distinguished specialist, and containing fifty pages and four good plates, being sold for 37½ cents? Yet that is the price of this first memoir.

It is written by the editor of the series, Professor W. A. Herdman, and the type treated is *Ascidia*, as might be anticipated from the editor's long and distinguished devotion to the group of animals of which this is a representative.

The series again is well-nigh unique in its origin and purpose. What these are may be best shown by extracting a paragraph from the editor's preface.

"In our twelve years, experience of a Biological Station (five years at Puffin Island and seven at Port Erin), where college students and young amateurs formed a large proportion of the workers, the want has been constantly felt of a series of detailed descriptions of the structure of certain common typical animals and plants, chosen as representatives of their groups, and dealt with by specialists. The same want has probably been felt in other similar institutions and college laboratories."

Some twenty other memoirs of like nature and by nearly an equal number of workers are promised.

It is hardly necessary to say that the number before us is scientifically accurate and up to date. It could hardly be otherwise; for its author has himself contributed more than any one else to the making of our knowledge what it is to-day, of the structure and speciography of the Tunicata. No one is better able than he to write such a book, and he has written it as well as he is able to.

The only instances in which I have noticed any doubtfulness or unclearness of statement are in connection with the pericardium and heart, and the coelom. On page 34 we are told that the "pericardial sac and its invagination the heart have formed in the mesoblast between the endostyle and stomach." A reader not already familiar with ascidian embryology would find difficulty, I should think, in harmonizing this statement with the clear statement of the fact found on page 10, viz.: that

the "pericardium [from which the heart itself is produced] and epicardium originate as outgrowths from the archenteron." Comparing the two statements such a reader *might* conclude that the first statement quoted means that the pericardial sac and its invagination are *embedded in* mesoblast as their formation proceeds, but he would also be justified in understanding the one statement to mean that the pericardial sac and hence the heart are of mesoblastic origin, while the other means that they are of hypoblastic origin.

Again the statement (page 10) that the cavity of the pericardium and epicardium 'may be regarded as coelomic spaces' is not exactly clear when compared with the statement made a few lines below on the same page, that the cavities of the renal vesicles and gonads are sometimes interpreted as being formed 'by a splitting of the mesoblast (*coelomic*).'

But the book is an admirable résumé of our knowledge of a typical ascidian, and if the succeeding numbers are equally satisfactory, the series cannot fail to be a potent factor in promoting the study of natural history not only in Great Britian, but as well beyond its borders.

It is unfortunate that the volumes could not be bound a little more securely, for they will hardly withstand the rough usage which they are pretty sure to receive as laboratory guides. If this could not be done without increasing the price, and if the price could not be increased even by a small amount, then it seems to me that it would be better to cut down the text and illustrations, particularly the former, somewhat, and apply the saving in expense thereby to making the binding better.

WM. E. RITTER.

GENERAL.

A LIMITED number of the reports of the University Geological Survey of Kansas still remain for distribution among persons who are interested in mining and geology. The publications to date include five volumes bound in cloth, and two annual reports on the Mineral Resources of Kansas bound in paper. All these may be had for the asking, except Vol. I., the supply of which is entirely exhausted. Persons writing for any or all of the reports should enclose the necessary postage, or request that they be sent by express. The volumes are: Vol. II., General Geology of Western Kansas, postage 26 cents; Vol. III., a Special Report on Coal, postage 28 cents; Vol. IV., Paleontology of the Upper Cretaceous, postage 32 cents; Vol. V., A Special Report on Gypsum and Gypsum Cement Plasters, postage 16 cents; Annual Report of Mineral Resources of Kansas for 1897, postage 4 cents; Annual Report on the Mineral Resources of Kansas for 1898, postage 7 cents.

MESSRS. D. APPLETON & COMPANY have nearly ready for publication *The International Geography*. Seventy authors have collaborated in its production, including the leading geographers and travelers of Europe and America. The work has been planned and edited by Dr. H. R. Mill, who also wrote the chapter on the United Kingdom. Among the authors are Professor W. M. Davis (The United States), Dr. Fridtjof Nansen (Arctic Regions), Professor A. Kirchhoff (German Empire), Mr. F. C. Selous (Rhodesia), Professors de Lapparent and Raveneau (France), Sir Clements Markham, F. R. S. (Ecuador, Bolivia, and Peru), Sir John Murray, F. R. S. (Antarctic Regions), Count Pfeil (German Colonies), Mr. James Bryce, M. P. (The Boer Republics), Sir H. H. Johnston, the late Sir Lambert Playfair, Sir F. J. Goldsmid, Sir Martin Conway, Sir George S. Robertson, Sir William MacGregor, Sir Charles Wilson, F. R. S., the Hon. D. W. Carnegie, Mrs. Bishop, Dr. A. M. W. Downing, F. R. S., Dr. J. Scott Keltie, and Mr. G. G. Chisholm. The book is illustrated by nearly five hundred maps and diagrams which have been specially prepared.

OTHER books announced for early publication by Messrs. D. Appleton & Co. include Comparative Physiology and Morphology of Animals, by Professor Joseph Le Conte; Some Great Astronomers, by Dr. Edward S. Holden, and the Story of Eclipses, by Mr. G. F. Chambers.

SCIENTIFIC JOURNALS AND ARTICLES.

WITH the December number the *American Naturalist* completes its twenty-third volume. Hermon C. Bumpus has the leading article, on

'Facts and Theories of Telegony,' which gives a brief review of the subject in general and of the recent experiments by Professor Ewart in particular. Edward Thorndike in a 'Note on the Psychology of Fishes' tells of a simple experiment by which it was shown that the common Fundulus could readily learn the proper route of escape from the compartment of an aquarium in which it was confined. C. E. Mead discusses '*Collops bipunctatus* as an Enemy of the Colorado Potato Beetle,' concluding that it is an important agent in protecting the potato crop. 'The Egg-Carrying Habit of Zaitha' is described by Florence W. Slater, and Robert T. Edes treats of the 'Relation of the Chirping of the True Cricket (*Oecanthus niveus*) to Temperature,' showing that the rapidity of the chirps increases with the temperature. 'Regeneration in the *Hydromedusa, Gonionemus vertens*' is discussed in detail by T. H. Morgan, whose experiments show that, although pieces smaller than one-eighth of the medusa may make new individuals having the medusa form, the remodeling does not include the internal organs. Richard C. McGregor has an article on '*Salvinia coccinea*, an Ornithophilus Plant,' describing the manner in which pollination is effected by humming birds, and the sixth instalment of 'Synopses of North American Invertebrates,' by W. P. Hay, is devoted to the *Astacidæ*. The reviews are numerous, and under Correspondence Henry B. Ward puts in a plea for the use of Mesenchyme.

The *Journal of the Boston Society of Medical Sciences* for December has for its first article an abstract of a paper by Charles S. Minot on the 'Classification of Tissues,' which takes the ground that this should be based on embryological data. W. F. Whitney describes some 'Malformations of the Kidneys,' and Thomas Dwight some 'Remarkable Skulls.' The final article 'Experiments on *Saphrolegnia ferax*, and their Application to the Trout Hatchery,' by J. H. Cunningham, Jr., is of much interest to fish culturists.

The Osprey for December opens with some 'Notes from Northern Counties of California,' illustrated by Milton S. Ray; this is followed by a reprint of J. E. Harting's article on 'The Largest Bird that Flies,' which is the subject of some interesting editorial comment. There is a brief biographical sketch, with portrait, of the late D. W. Prentiss. The editorial columns contain a description of the recent meeting of the American Ornithologists' Union, and among the letters is the prospectus of the Third International Ornithological Congress, to be held in Paris during the coming year, and a record of the bird arrivals at Dawson.

SOCIETIES AND ACADEMIES.

NEW YORK ACADEMY OF SCIENCES.
SECTION OF GEOLOGY AND MINERALOGY.

At a meeting of the section on December 18, 1899, in the absence of the Chairman, Professor J. J. Stevenson was elected temporary chairman. Twenty-six persons were present.

Professor J. F. Kemp presented a paper on 'Recent Theories Regarding the Cause of Glacial Climate.' During the subsequent discussion of this paper by Professors R. E. Dodge, D. S. Martin and others, Professor Stevenson called attention to the fact that the great excess in the area of the peat bogs on the surface of the earth, during the present period, over that of the swamps which prevailed during the Carboniferous, shows the little foundation for the hypothesis of an excess of carbon dioxide in the atmosphere during the formation of the coal. Dr. Julien also pointed out, in reference to the theory of the refrigerating influence of the absorption of carbon dioxide from the atmosphere, during the decay of rocks, that this effect may have been more than offset by the heat produced during the accompanying absorption of oxygen.

Professor Kemp then read a paper on 'Metamorphosed Dikes in the Mica Schists of Morningside Heights.' This paper was discussed by several members. Dr. Julien acknowledged the resemblance of this outcrop of black hornblende schist to a sheared dike, produced by its strong contrast in color with the enclosing light gray micaceous gneiss, and by the sharp lines of separation of the schist from the highly tilted beds on either side, as if thrust up from below. Yet this is but one of hundreds of exactly similar outcrops in New York and Westchester

Counties. All are intercalated, however, as thin beds in the Manhattan Series; in not a single case has a hornblende schist been observed to cross the other beds. If one or all of these are dikes, the lamination of the associated beds must also have been effected by a general shearing. But the series is accepted as typically metamorphic, a succession of true beds of altered sandstone (quartzitic gneiss), shales (mica schist), magnesian schists (dolomite marble), etc., into which the injection of trap dikes exclusively between the beds would be entirely improbable. These hornblende schists, moreover, on Morningside Heights, as elsewhere, thin out along the strike like the other lenticular beds, often become partially or entirely biotitic and quartzose, passing gradually into biotitic schists, biotitic and hornblende gneisses, exactly like those of acidic constitution which enclose the above supposed dike. Indeed, a basic element, rich in lime and magnesia, is distributed throughout the Manhattan Series, and was originally perhaps hornblendic throughout, or, in the absence of silica, concentrated in the numerous dolomite beds. The more purely hornblendic layers correspond in composition, as shown by the interesting analysis in the author's paper, to beds of altered marl; their density has enabled them to resist and escape, in the present surviving layers, the biotitic alteration which has affected the general series.

A paper was then presented with lantern illustrations by Mr. W. D. Matthew, 'Notes on the Geology of the Laramie Plains and Rattlesnake Mountains in Wyoming.' Professor H. F. Osborn remarked on the uncertainty of the age of the *dinosaur*-beds, whether Jurassic or Lower Cretaceous. All determinations hitherto have been made by collectors, but neglected by the paleontologists, though the section is here continuous from the Mountain Limestone of the Carboniferous up to the base of the Cretaceous. Nor has the correlation yet been made with the corresponding beds of the Wealden, Purbeck, etc., of England and the European Continent. The æolian theory of the author, however, does not appear consistent with reported observations of remains of aquatic life in these beds. The Chairman stated that no true Mountain Limestone fossils have yet been detected in the bed so called in Wyoming, nor the good evidences yet needed of Jurassic life in the *dinosaur*-beds, of other vertebrate life, lacustrine remains, etc., of that age, and for confirmation of synchronism of Jurassic life between the continents. As to the heavy oils of Wyoming, they contain but little paraffin and perhaps less than twenty per cent. of kerosene, and are likely to be worthless, except possibly hereafter for use as a coarse fuel. The paper was further discussed by Professors Dodge, D. Van Ingen and others.

ALEXIS A. JULIEN,
Secretary of Section.

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON.

THE 297th regular meeting of the Society was held Tuesday evening, December 19, 1899.

Mrs. M. C. Stevenson read a paper on 'Zuni Games,' in which several ceremonial games were technically described, and the errors of other observers and writers pointed out. The author claimed that these errors were due to a superficial acquaintance, not only of the game itself, but to the lack of familiarity with the people and their language. It was necessary to live a long time with them in order to discover the true meaning of many of the details.

Dr. J. H. McCormick read a paper entitled 'The Supernatural in Primitive Concept,' in which he traced the origin and development of primitive ideas of religion and pointed out the four universal primitive doctrines of Physianthropy, Animism, Transmigration and Anthropomorphism, and the influence exercised by each upon such concepts.

Mr. George R. Stetson gave 'Some Curiosities of Philological Literature.'

Mr. Stetson examined the literature of Comparative Philology from the point of view of the student "who is disturbed if not somewhat appalled by the prevailing confusion and contradictions in the understanding and application of the technical terms used by philologers."

In behalf of the inquirer whose mental vision is obscured by the divergent concepts and theories advanced by the various professional writers in regard to the origin of speech, and the

genesis, formation, growth and classification of language, Mr. Stetson appealed to the latter to exercise greater care in announcing, and greater diligence in seeking for unanimity in their concepts.

He suggested that, in order to prevent the existing confusion among professional writers as well as among students, it was imperative that a line be drawn and a classification adopted which shall definitively separate the crude, fluctuating, undeveloped, and unrefined speech of a narrowly circumscribed region—*i. e.*, the 'dialectic stage'—from the comparatively fixed and highly developed inflected speech of an extensive area, or the 'cultivated stage.'

That patois and dialect should cease to be used as synchronal or equivalent terms, as in the history of language the former represents the destructive and the latter the constructive period.

That the use of 'dialect' as a relative term, by which the meaning of the 'dialect' and 'language' is made to depend upon the connection in which the terms are used should be abandoned, in the interest of clear thought and intelligible classification.

That writers should more particularly differentiate 'speech' from 'language,' and, in comparative philology, the study of the affinities of language, from linguistics, the study of the derivation of words.

That the classification and relations of dialect, language, patois, and jargon be more absolutely defined and rescued from their present confusion by some authoritative body.

That the aim of writers on comparative philology and experts in linguistics should be to more completely separate the conceptual and hypothetical from the practical and profitable, and thus prevent the needless waste of thought and effort.

"That more is to be learned from analogy and living speech, as Professor Sayce suggests, than from dead literature," or it may be added from the questions of origin and precedence.

In conclusion Mr. Stetson remarked that he did not wish to convey the impression that the absence of unanimity in concepts and confusion in terminology is peculiar to the writers on philology; he feared that they might be found in a greater or less degree in all philosophical inquiries.

He also expressed the opinion that students generally, in view of the prevailing contradictions, the dearth of recorded facts, and superabundance of hypotheses, are not inclined to accept without question the present claim of comparative philology as a science, and that while extremely valuable work has been and is being done,—especially in the division of linguistics, a study which has been practically born within our memory,—its essays and instruction are too frequently founded upon hypotheses "which furnish no perceptible evidence of truth or of value in their practical application."

J. H. McCormick,
Secretary.

DISCUSSION AND CORRESPONDENCE.

HOMOLOGIES OF THE WING VEINS OF HYMENOPTERA.

Very important investigations of the morphology of the venation of the wings of insects have recently been made by Professor Comstock in his 'Manual for the Study of Insects,' published in 1895, and more recently by Comstock and Needham, in a series of articles published in the *American Naturalist*, 1898–99, reissued as a pamphlet of 124 pages and 90 figures by the Comstock Publishing Company.

While I accept their principles, the application of them and a comparison of the figures lead me to a different conclusion with regard to homologies of the wing-veins of hymenoptera, which in connection with my studies of the bees it has been very important for me to work out. In the Manual vein *M* is regarded as three-branched, as in the diptera, but in the later articles this vein is regarded as four-branched.

In the first place I regard the wing of *Macroxyela* (Manual, p. 606, fig. 705) as a better example of the typical hymenopterous wing than the composite wing produced by a combination of the wing of *Macroxyela* and *Pamphilius* (*Am. Nat.*, 414; figs. 38–39). But the latter will illustrate my views.

My conclusions are: that the cross-vein *m* connects M_2 and $M_3 + Cu_1$, as in the wing of

Pantarbes (40) and *Rhamphomyia* (41), and that the cross-vein marked *m—cu* in *Leptis* (*Am. Nat.*, 32; 337, fig. 30) does not exist in the hymenoptera, but is obliterated by the coalescence of the above-mentioned veins; M_4 is Cu_1, and Cu_1 is Cu_2; the cross-vein marked *m—cu* is not homologous with the one so marked in *Leptis*, but belongs to the *arculus!* To account for the vein marked Cu_2 I should say that it is before the arculus and does not enter in the consideration of the ordinary cases. According to the authors, this vein does not occur in any of the hymenoptera, except *Pamphilius.*

If my view is correct, a large part of the peculiarities of the venation of hymenoptera is connected with the great lengthening of the arculus and the shifting of it from the base of the wing.

The only changes in the designation of the cells which my attempt at elucidation involves are: M_3 is Cu_1; Cu_1 is *2nd Cu*; *Cu* is *1st Cu*; *M* is homologous with the cell marked *1st M* in *Scenopinus* (*Am. Nat.*, 32; 339, fig. 36); M_4 is the same as the cell marked *2nd M* in *Scenopinus* and the cell marked *M* in *Rhamphomyia* (41).

CHARLES ROBERTSON.

NOTES ON INORGANIC CHEMISTRY.

A GOOD illustration of how much material there is in inorganic chemistry which needs reinvestigation, is found in the fact that there has been no general method of forming the sulfids of the rare earths, nor have any of the sulfids been obtained in a pure condition, with the possible exception of that of cerium. This gap has now been filled by Muthmann, of Munich, in conjunction with L. Stützel. They find that while the oxids are very slowly converted into sulfids when heated in a stream of hydrogen sulfid, the anhydrous sulfates are, under the same conditions, very readily converted quantitatively into the sulfids. The sulfids of cerium, lanthanum, neodymium and praseodymium were formed in this way, and their properties, physical and chemical, studied. They are fairly stable in the air at ordinary temperature, but are decomposed with evolution of hydrogen sulfid by warm water or dilute acids. They take fire readily on heating in the air, and when finely divided the cerium sulfid often proved pyrophoric. They burn to a mixture of oxid and sulfate. On heating in a current of dry hydrochloric acid, they are readily and quantitatively converted into the anhydrous chlorids, and on a small scale this is the best and easiest method of preparation of these chlorids. The study as a whole, which is published in the last *Berichte*, is a valuable contribution to the chemistry of the rare earths.

IN a series of experiments by A. Petterson, of Upsala, printed in the *Klinische Wochenschrift* (Berlin), the fact is established that in meat and fish preparations, containing 15% of salt for the purpose of preservation, a constant and luxuriant growth of microörganisms takes place. From this the conclusion is drawn that the special flavors, odors, consistencies, and colors of salt conserves are chiefly produced by various microörganisms.

THE subject of food preservatives is also discussed from a different standpoint by R. Kayser, of Nuremberg, in the *Zeitschrift für öffentliche Chemie.* In earlier times, the tendency of various foods to decomposition was counteracted by drying, smoking, pickling and the like. In some cases special processes were used, as the treating wine with sulfur, beer with hops, etc. At the present day, scientific progress has led to the use of low temperatures, of sterilization, and especially to the use of chemicals. In this last case the demand is made that the preservatives used shall not only be harmless in the quantities used, but inert to the human system even in vastly greater quantities than ever used in foods. This demand, it is pointed out, is unprecedented, for it is not complied with under old methods. Common salt, saltpeter and creosote are present in these and are not less injurious in quantity than the more recently used boric acid, borax, salicylic acid, benzoic acid, etc. There are no authentic instances on record of injury from the use of any of these in foods, while there are very many instances of injury from foods which, apparently good, were in reality decomposed (presence of ptomains, etc.). The whole subject needs to be treated in a more rational way.

THE latest numbers of the *Chemical News* contain reprints of several papers on the new radiant substances discovered by M. and Mme. Curie. It is found that the radio-activity of polonium and radium can be communicated by contact to inactive bodies, such as many metals, paper, barium carbonate and bismuth sulfid, and this induced radio-activity persists for a considerable time.

MME. CURIE has concentrated by fractionation the radium which is associated with barium in the uranium minerals, and determined the atomic weights of the successive fractions—one fraction having an activity 3000 times that of uranium had an atomic weight of 140. (Ba = 137.8.) A later fraction of 7500 times uranium's activity had an atomic weight of 145.8, hence it seems that radium has a higher atomic weight than barium. In this work half a ton of uranium mineral was used and the radiferous barium chlorid which was fractionated amounted to two kilos. The spectrum of this concentrated radium was studied by Demarçay, and in addition to the spectrum of barium, very intense and complete, a series of new lines was found and measured. Some of these are very characteristic. It thus appears reasonably certain that radium has a definite position as a chemical element, and the properties of the purified substance will attract great interest when determined. Among the chemical effects of the salts of radium is the conversion of oxygen into ozone. This phenomenon seems to be connected rather with the radio-activity than with luminosity. Radium carbonate is very luminous, but produces less ozone than radium chlorid, which is much less luminous, but more strongly radio-active. If a radium salt is placed in a glass vessel, a violet coloration is seen in the glass which proceeds from the interior to the exterior. In ten days or so the bottom of the flask is almost black. This takes place in glass containing no lead. The effect of the Bacquerel rays upon barium platino-cyanid is also chemical. All these phenomena point to the fact that the rays emitted by radium present a continual development of energy.

J. L. H.

CURRENT NOTES ON METEOROLOGY.

THE WEST INDIAN HURRICANE OF AUGUST, 1899.

AN account of the West Indian hurricane of August 7–17 last, in the *Monthly Weather Review* for August (issued October 30), brings out several points worth noting here. The report from the Weather Bureau observer at Arroya, Puerto Rico, says that the Spanish steamship *Alava* took refuge in the Port of Jobos, and with all her anchors down and working full speed ahead, she dragged for half a mile. At Aguadilla, Puerto Rico, the passage of the calm central 'eye' of the storm occupied about one hour. At Nassau, considerable damage was done by the northeast wind, which backed to northwest, and fell calm. People then came out to gather up their scattered effects, when the wind suddenly began to blow from the southwest with great force. An aneroid reading of 27.75 inches, corrected for instrumental error and for elevation, was made at Guayama, Puerto Rico, and one of 28.11 inches was made at Juana Diaz.

RECENT PUBLICATIONS.

NOTE.—The unusually large number of recent publications of importance makes it necessary, in view of the limited space, to restrict our mention of them to a few lines only.

EVELYN B. BALDWIN: 'The Meteorological Observations of the Second Wellman Expedition,' *National Geographic Magazine*, December, 1899, 312–316. Mr. Baldwin is an official of the United States Weather Bureau, and was equipped with instruments by the Bureau. This is a preliminary report of his meteorological work.

FRANK H. BIGELOW: 'The probable State of the Sky along the Path of Total Eclipse of the Sun, May 28, 1900, Observations of 1899,' U. S. Department of Agriculture, Weather Bureau. Bulletin No. 27. 8vo. Washington, D. C., 1899. Pp. 23. Charts IV. This report summarizes, for the information of astronomers and others interested in the approaching eclipse, the results of observations made in 1897, 1898 and 1899 to determine the prevailing average cloudiness in the districts covered by the eclipse track.

FRANK H. BIGELOW: 'Some of the Results

of the International Cloud Work for the United States,' *American Journal of Science*, December, 1899, 433–444. A preliminary statement of results which are soon to be published *in extenso* by the Weather Bureau.

OLIVER L. FASSIG: 'Types of March Weather in the United States,' *American Journal of Science*, November, 1899, 319–340. A discussion of the relations existing between the mean atmospheric pressure, the prevailing character of the weather and the paths of storms.

WILLIS L. MOORE: 'Report of the Chief of the Weather Bureau for 1899,' U. S. Department of Agriculture, Weather Bureau. 8vo. Washington, D. C., 1899. Pp. 23.

B. S. PAGUE: 'The Mild Temperature of the Pacific Northwest, and the Influence of the Kuro Siwo.' 8vo. Portland, Ore., 1899. Pp. 11. Charts III. The author classifies the temperature conditions of the north Pacific Coast into continental, dynamic and oceanic types. He believes that dynamic heating of descending air is more effective than the influence of the ocean in producing the mild winter temperatures of the Pacific Northwest.

R. DEC. WARD.

HARVARD UNIVERSITY.

RECENT ZOOPALEONTOLOGY.

Adaptive radiation of the Camels and Llamas.—Professor Scott advances the following hypothesis in his recent important memoir:

"The most interesting and striking result to which the study of the Uinta selenodonts has led is the very unexpected conclusion that, with the possible exception of the *oreodonts* and *agriochoerids*, all of the strictly indigenous North American *selenodonts* are derivatives of the tylopodan stem. Paradoxical as this conclusion may appear, I believe it to be fully justified by the evidence which will be laid before the reader. The Tylopoda are thus seen to be a very ancient and highly diversified group, comparable in this respect to the Pecora, or true ruminants, which they so closely resemble in many features. The Pecora are an Old World group, which underwent great expansion and diversifications in Eurasia, but did not reach this continent till late Miocene times, and never attained the importance here that they have so long had in the Eastern Hemisphere. Their place was, to a very great extent, taken in America by the Tylopoda, which ran a course of development in many ways parallel to that of the Pecora and Tragulina, but with a variety and diversity of structure, habit, and appearance, such as are not attained in either of the latter groups." It has long been known that the Camels and Llamas had their home on this Continent, but Professor Scott's hypothesis, that practically all the American Artiodactyls, except the pigs, sprang from a common cameloid stem, is of the greatest interest. If confirmed, it will take rank as a brilliant generalization resulting from recent exploration. Even if not confirmed, it will be of great value as stimulating closer inquiry into the natural relationships of the American even-toed Ungulates. *Trans. Wagner Free Institute*, Phila., May, 1899, Vol. VI.

The Pliocene Hyrax.—*Pliohyrax* Osborn is identical with *Leptodon* Gaudry. This rather dry announcement relates to an interesting extension of our knowledge of the Hyracoidea. For some years a skull found upon the Island of Samos awaited description in the Stuttgart Museum; Professor Fraas kindly placed it in the hands of Professor Osborn, who described it before the International Zoological Congress, at Cambridge, as a new and very remarkable form of *Hyrax* from the Lower Pliocene, as the only fossil representative of this order and as belonging to a distinct family of Pliohyracidae and a distinct genus *Pliohyrax krupii*. It now appears that the lower jaw found by Professor Gaudry in Pikermi, Greece, and long known as *Leptodon graecus* belongs to the same type as the above. Dr. Max Schlosser, of Munich, points this out in an interesting article in the *Zoologischen Anzeiger* of October. He leaves the animal among the Hyracoids and suggests that it is of South American origin, a suggestion of considerable probability and of very great interest.

Exploration for Dinosaurs.—Great activity prevailed last season in the search for the remains of Dinosaurs. A report of the parties exploring in the Dinosaur beds under the direction of Professor W. C. Knight has already been made in this JOURNAL. In addition to

the scattered fossils thus secured by representatives of many institutions, there were five fixed parties in the field. The three representing the Field Columbian Museum, the University of Wyoming, and the University of Kansas had their quarries in the Freeze Out Mountains. A few miles to the east was the Carnegie Museum party under the direction of Dr. Wortman; they found a very promising locality in which a large portion of a skeleton of Diplodocus was secured. To the southeast was the American Museum party, which continued the excavation of the 'Bone Cabin Quarry' with good results, and four miles west of this point secured a considerable part of a Brontosaur skeleton. In the quarry itself the greater portion of a Mososaur skeleton was found in a very much crushed condition. Altogether the general work of the season will greatly advance our knowledge of the Dinosaurs. At the same time the beds in the Como region have been so thoroughly explored that it is becoming very difficult to find these animals, and when found it is very difficult to take them out.

Ear bones of Marsupials.—According to Richard Weil,* the ossicula auditus of the opossum are not at all parallel in their development with those of the pig, considered as a representative of the Placental mammals. This tends further to confirm the conclusion, arrived at from many other grounds, that Marsupials are entirely to be regarded as forms parallel to the Placentals rather than as ancestral forms. As regards the origin of the malleus, Weil's investigation confirms the prevailing opinion that it is derived from Meckel's cartilage or the mandibular arch. The incus also arises from the mandibular arch and has no relation to the hyoidean arch. Mr. Weil believes that Kingsley has placed too much dependence upon the relation of the nerves to these elements. Weil's results directly contradict the theory of Reichert, Huxley and others, that the quadrate of the Sauropsida is represented in the auditory chain of Mammals, for according to his observations the quadrate belongs not to the mandibular arch from which the Mammals derive their ear bones but to the palatoquadrate bar.

The Fins of Ichthyosaurus.—Professor Fraas, of Stuttgart, describes the most perfect specimen of an Ichthyosaur which has yet been found in the famous quarry in Holzmaden. It exhibits in a remarkable manner the structure of the fins, having been worked out with the utmost care by Herr Bernhard Hauff for the Royal Geological Museum of Hungary. Although partly described by Owen, the complete dermal structures of Ichthyosaurs were first discovered in the Holzmaden quarry in 1892. Five specimens have been found altogether in a somewhat restricted part of the quarry. The skin impressions are of a light brown to a deep black color with a grayish slate blackground, and are so fine that they must be exposed with the greatest skill by the use of a fine scapel working under a magnifying lens. The specimen here described gives a perfect picture of the dorsal and caudal fins and of the fin folds surrounding the paddles. The irregular folds behind the dorsal fin represent a displacement of a portion of the pigmented skin from the sides of the body. The caudal fin is remarkable in the elongation of its upper lobe, but it is not at all evident how this lobe was supported, since, unlike the sharks, the tail vertebræ turn down into the lower lobe.

H. F. O.

* *Annals N. Y. Acad. Sci.*, Vol. XII., No. 5. Pp. 103 to 118, July 7, 1899. 'Development of the ossicula auditus in the opossum.'

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*AGRICULTURAL EXPERIMENT STATIONS.**

THE most obvious indication of the success of experiment stations as a means for improving agricultural conditions in this country is the steady increase in the number of stations and station officers, and in the amount of financial support which they have received from the National and State governments. In the first volume of the *Record* it is stated that in 1889 there were 46 stations in the United States, receiving an aggregate revenue of about $725,000, of which $600,000 was appropriated from the National Treasury and $125,000 was received from State governments and other local sources. The total number of persons engaged in the work of the stations and at this office that year was 402. In 1898, the last year for which statistics have been compiled, the total number

* From *Experimental Station Record.*

of stations was 54. Their total income was somewhat over $1,200,000, of which $720,000 was received under the Hatch Act (in addition to $35,000 for this office) and $480,000 from State governments and other local sources. The number of officers had increased to 669.

With the increase in the number of the stations and the enlargement of their resources, there has been a corresponding increase in the number and variety of their publications, and these have been more thoroughly distributed each year. Besides the vast amount of agricultural information which has thus been generally diffused among our farmers, either directly through station publications, or indirectly through the public press, more than fifty books on strictly agricultural subjects have been written by station men during the past ten years, and the results of the work of the stations are being largely incorporated in books whose authors are not connected with the stations. It requires only a superficial retrospect to discover a very remarkable difference in the freshness of material and the thoroughness of treatment of the published information available to our farmers ten years ago and that which is at their command to-day. It is most encouraging to observe that, despite the pessimistic predictions in certain quarters, the output of carefully prepared books for the farmer's use has notably increased within the past few years, and American books for the American farmer are written from an American standpoint, and on the basis of accurate information obtained by American investigators.

SCIENTIFIC NOTES AND NEWS.

WE regret to record the death in New York on January 15th of Dr. Thomas Egleston, emeritus professor of mineralogy and metallurgy in Columbia University.

AT the January meeting of the American Academy of Arts and Sciences, Boston, Professor William M. Davis was chosen corresponding secretary in the place of Mr. Samuel H. Scudder, resigned.

M. MÉRAY has been elected a correspondent of the section of geometry of the Paris Academy of Sciences.

PROFESSOR RÖNTGEN, who has accepted the call to the University of Munich, has been appointed director of the State Institute of physics and metrology.

MR. W. N. SHAW, of Emanuel College, Cambridge, has been chosen to succeed Mr. Scott at the British Meteorological Office.

MM. RADAU AND BIGOURDAN have been presented by the Paris Academy of Sciences to the Minister of Public Instruction, who will select one to fill the vacancy in the Bureau des Longitudes, caused by the death of M. Tisserand.

PROFESSOR G. FREDERICK WRIGHT, of Oberlin College, has been given a leave of absence for a year and three months. He will make geologic studies in the Sandwich Islands, Japan, Russia, Egypt, Italy and other countries.

ON the twenty-fourth of December, 1899, the Physico-Mathematic Society, of Kazan, Russia, celebrated a jubilee in honor of the twenty-fifth year of professorial and scientific service of its President, Professor A. Vasiliev. It is also the fifteenth year of his presidency. Professor Vasiliev has been an important figure in Russian science. His discourse on Lobachevski has been translated into English by Professor Halsted, and a German translation of his book on 'Tchebychev' is to be published this month by Teubner at Leipzig. The first volume of an edition of 'Tchebychev's Collected Works,' in French, has just appeared, edited by the Academicians Markof and Sonine. It contains a fine portrait of the great mathematician and the first thirty-four memoirs of Vasiliev's list.

THE two books, Whitehead's 'Universal Algebra' and Killing's 'Einführung in die Grundlagen der Geometrie,' which were particularly signalized in Professor Halsted's Report on Progress in Non-Euclidean Geometry recently published in this JOURNAL, have been entered in competition for the Lobachevski prize of 1900.

THE American Society of Naval Engineers has awarded its first prize for the best technical essay submitted to Professor W. F. Durand of Cornell University, for his paper on 'Electrical Propulsion for Torpedo Boats.' The prize consists of a substantial compensation, life membership in the Society, and a gold medal. The second prize has been awarded to D. C. Ball, late of the Engineer Corps, and now a consult-

ing engineer in New York, for his paper on 'Interior Diagrams for Multiple Expansion Engines.'

THE University of Lyons has received a legacy of 50,000 francs for the establishment of a prize to be awarded every five years to a resident of the city or neighborhood who shall have contributed to the advancement of hygiene or medicine.

M. BISCHOFFSHEIM has given to the Paris University the observatory established by him at Nice at a cost of 2,500,000 francs, together with an endowment of the same amount.

THE government has appropriated 13,000 Marks for mounting the 12-inch photographic telescope presented to the University of Heidelberg. Two thousand Marks have been given to the Scientific Society of Heidelberg for publication.

ANDREW CARNEGIE has promised the College of Emporia, Kan., $50,000 for a library building as soon as the present debt is paid.

DR. DOMENIK JOSEPH RITTER VON HAUSCHKA, formerly professor of medicine at Vienna, has died at the age of 84 years.

AT the last meeting of the Council, the Ottawa Field Naturalists' Club, Dr. Ami in the chair, the following gentlemen were nominated a committee of the Club on the Billings Memorial: Mr. J. E. Whiteaves, Sir James Grant, Dr. James Fletcher, Mr. Walter R. Billings, Mr. Byron E. Walker (Toronto), Mr. W. J. Wilson (Secretary of the Club), and Dr. H. M. Ami. A handsome sum of money has already been subscribed, and it is confidently expected that sufficient funds will be raised to pay suitable tribute to the memory of one who has done much to advance researches in paleontology and natural history in North America.

THE report of the Executive Committee of the New York Zoological Society shows that the Society has a total membership of 736, an increase of 136 over last year. The committee during the last year added $49,760 to the Park's fund, making $160,779 in all. The City had, however, cut the Society's allowance to $40,000 from $60,000. It was stated that the most pressing needs of the Society for new buildings could be met for $75,000. The following were elected members of the Board of Managers of the class of 1904: Ex-Gov. Morton, Andrew Carnegie, Morris K. Jesup, John L. Cadwalader, Philip Schuyler, John S. Barnes, Madison Grant, William White Niles, Samuel Thorne, H. A. C. Taylor, William D. Sloane, and Hugh J. Chisholm.

THE report of the Palisades Commission, which has been in communication with a similar commission from New Jersey, was made to Governor Roosevelt at Albany, on January 12th. It presents a bill providing for an appropriation of $250,000 to the National Government for Palisades Park purposes, in addition to land ceded in Rockland County. "While New York has a vastly greater material interest in the preservation of the natural scenery of the Palisades than has New Jersey," the commission says, "the former has offered to the National Government only an unimportant contribution in its very limited length of water front on the Hudson, while the State of New Jersey has offered to give property valued at upward of $750,000. It seems equitable that New York should tender in money what she lacks in land. With such an equalization of the burden, it is deemed not unlikely that all three parties may be brought into harmony in the carrying out of the proposition to preserve the Palisades."

THE sixth annual series of University Lectures in Biology, at Columbia University is being given by Professor Thomas H. Morgan, of Bryn Mawr College, on the subject of 'Regeneration and Experimental Embryology.' The dates and subjects are as follows: Jan. 16th, General Phenomena of Regeneration; Jan. 19th, The Conditions that Influence Regeneration; Jan. 23d, Special Problems of Regeneration and Development, Specification of the Tissues; Jan. 26th, Development of the Egg in the Light of Experimental Embryology; Jan. 30th, The Relations of Growth, Development and Regeneration. The lectures are given at 5 p. m. in Schermerhorn Hall. No tickets are required.

POSITIONS of library clerk in the Department Division of Forestry and of associate ethnologic librarian in the Smithsonian Institution will be filled by Civil Service examination during Feb-

ruary. The position of assistant and expert in forestry history, at a salary of $1000 per annum, will also be filled in February as the result of an examination. Details regarding these, as of all other Civil Service examinations, can be obtained by addressing the U. S. Civil Service Commission, Washington, D. C.

AN examination will be held on February 6th for the position of draughtsman in the Geological Survey. The candidates should have experience in the preparation of drawings of invertebrate fossils.

THE Civil Service Commission of New York State will hold open competitive examinations on or about January 27, 1900, in various cities throughout the State, for the position of chemist, State Board of Health, with a salary of $125 per month. The examination will consist entirely of practical questions relating to analysis of food products, and questions relating to experience and training of the candidates; candidates having applications on file will be given ample notice of the time and place of examination most convenient to their places of residence.

A STATE department of Trade, Art and Commerce has been established for the Russian Empire.

THE Liverpool School of Tropical Medicine proposes to organize an International Conference on Malaria.

A CONGRESS on Tuberculosis will take place at Naples in the spring of 1900. The Congress, in connection with which there will be a great hygienic exhibition, is under the patronage of the Queen of Italy. Professor Baccelli, Minister of Public Instruction, will preside. A German committee has already been formed to assist in making arrangements for the Congress.

WE learn from the London *Times* that several prominent English medical men have been staying in Rome for some days. They visited the scientific and academic institutions and devoted special attention to the researches of Professors Grassi, Bignami, Celli and Dionisi, in connection with malaria. Arrangements were made for the maintenance of continual intercourse between the Roman School of Hygiene and the London School of Tropical Medicine. The English doctors visited various hospitals and conferred with the Minister of Public Instruction, who promised to be present at the official inauguration of the tropical school in London.

AT the annual meeting of the New York Neurological Society, held January 2d, the following officers were elected: *President*, Frederick Peterson; *First Vice-President*, Joseph Collins; *Second Vice-President*, L. Stieglitz; *Recording Secretary*, Pearce Bailey; *Corresponding Secretary*, Lewis A. Conner; *Treasurer*, Graeme M. Hammond; *Councillors*, C. L. Dana, M. A. Starr, B. Sachs, E. D. Fisher and J. Arthur Booth.

AT a meeting of the Zoological Society of London, on December 17th, Dr. P. L. Sclater, the secretary, read a report on the additions that had been made to the Society's menagerie during the month of November, 1899, and called special attention to two snake-fishes (*Polypterus senegalus*) from the river Gambia, obtained by Mr. J. S. Budgett, F.Z.S., during his recent expedition to the Gambia, and presented by him on November 22d. These were believed to be the first examples of this fish ever brought alive to Europe.

THE German Emperor began an address to the officers of Berlin garrison on January 1st with the words: "The first day of the new century sees our army," etc., and the day has been celebrated in Berlin as the first day of the twentieth century.

UNIVERSITY AND EDUCATIONAL NEWS.

BY the will of the late Dorman B. Eaton, Columbia University receives $100,000 to found a professorship of municipal science and administration, and Harvard University $100,000 to endow a chair in the science of government.

MR. LOUIS H. SEVERANCE, of New York City, has given $60,000 to Oberlin College for a chemical laboratory. The provision made for the College by Mrs. C. E Haskell amounts to $77,000..

DR. ALONZO E. TAYLOR, who, as we recently announced, has been called from the William Pepper Laboratory of the University of Pennsylvania to the professorship of pathology in the University of California, is at present in Berlin arranging for the purchase and construc-

tion of instruments for the new laboratories. Mrs. Hearst has provided for the equipment of the department of pathology, including bacteriology, general and special morphological pathology, and pathological chemistry, as also microscopes for the department of anatomy. The equipment of the department of pathology will be very complete and will provide especially for research work.

THE sum of 17,000 Marks has been appropriated for apparatus for the new physical laboratory at Breslau.

THE bequest of $25,000 by the late E. F. Holden to Syracuse University will be used for the department of astronomy and for the observatory.

OWEN'S COLLEGE, Manchester, receives £1000 from the will of the late P. G. J. Ermen.

THE medical faculty of McGill University is arranging courses on legal medicine and public health.

THE College of Science of the University of Illinois has issued a circular offering a four years' course in natural science, the special object of which is to prepare for work in economic entomology. The principal studies of this course are three years' work in entomology (the last of which will be practically original research carried on under general supervision and advice), a year of chemistry, a half year of physics, mathematics and drawing, two years of German and one year of French, half a year of agriculture (agricultural crops), a year of horticulture (a three-fifths course), and a half year each of elementary biology, invertebrate zoology, human physiology, general botany, bacteriology and geology. To these are added, as minor courses, the military physical training, and rhetoric required for graduation. The courses in agriculture, horticulture and botany are so selected as to give the kind of knowledge and experience especially needed by the economic entomologist, and those in elementary biology and general zoology lay a foundation of training and instruction for the special studies of the entomological course. Students graduating from this course will receive the degree of B. S. in natural science.

THE attendance of regular students at the University of Berlin this winter is 6478, which is an increase of 605 students over the registration last winter. The increase is the largest in the faculties of philosophy and law. The University of Berlin has more than three times as many students as it had twenty-five years ago.

THE Rev. B. L. Whitman, D.D., since 1895 President of Columbian University, Washington, D. C., has resigned to accept the pastorate of the Calvary Baptist Church in Philadelphia. Dr. Whitman's resignation will take effect on June 1st, next.

BENJAMIN LINCOLN ROBINSON, Ph.D., has been appointed Gray professor of botany at Harvard University.

DR. HANS STOBBE has been promoted to an associate professorship of chemistry at Leipzig.

DR. LUTHER has qualified as docent in physical chemistry at Leipzig and Dr. Ley in chemistry at Würzburg.

THE Degree Committee of the Special Board for Physics and Chemistry, at Cambridge University, are of opinion that the work submitted by Richard Smith Willows, of Trinity College, advanced student, comprising papers (1) On the Variation of the Resistance of certain Amalgams with Temperature (*Phil. Mag.*, November, 1899); and (2) On the Distance between the Striæ in the Positive Column and other Phenomena connected with the Discharge, is of distinction as a record of original research.

DR. J. FRISCHAUF, professor of mathematics at Graz, has been suspended, apparently for criticising his colleagues in the newspapers.

THE New York *Medical Journal* states that Dr. S. L. Schenk, professor of embryology and histology, and director of the Embryological Institute at the University of Vienna, has been retired on a pension. This action is in answer to a petition of the medical faculty of the university alleging the publication in the lay press of scientific theories constituting a form of advertisement. Dr. Schenk, it will be remembered, published a saccharine theory of sex production. He had been a director of the Embryological Institute for twenty-six years.